BRIEF INTRODUCTORY PSYCHOLOGY FOR TEACHERS

E. K. STRONG, Jr.

BRIEF INTRODUCTORY PSYCHOLOGY FOR TEACHERS

BRIEF INTRODUCTORY PSYCHOLOGY FOR TEACHERS

BY

EDWARD K. STRONG, Jr.

CARNEGIE INSTITUTE OF TECHNOLOGY

BALTIMORE, MD.

WARWICK & YORK, Inc.

1922

THE MAPLE PRESS YORK PA

To My Father and Mother

PREFACE

Certain principles have been established as fundamental to good teaching. Theoretically, all psychologists are agreed that a course of study should proceed from the known to the unknown and from the concrete to the general; that students should learn by doing; that the problem or project method of teaching is superior to memorization of a textbook; that functional not faculty psychology should be taught; that individual differences in students should be taken into account; that a beginning course should be designed for the benefit of the great majority who never go farther; etc.

The aim of this course is to meet these and other ideals of teaching in an introductory course of psychology designed primarily for the use of prospective teachers. Instead of beginning with the most uninteresting phases of psychology and those most unknown to students, the course takes up concrete experiences of everyday life, relates them to the problems of learning, individual differences, and influencing others, and so develops these topics. Each general principle is discovered by the student out of his own experience in solving specially organized problems. Only after he has done his best is he expected to refer to the text and by then the text is no longer basic but only supplementary, clearing up misunderstandings and broadening the whole viewpoint. Behavior as a whole is considered from the start; gradually it is subdivided and subdivided, so that finally such topics as "memory" or "attention" can be discussed without fixing in the mind of the student the idea that they are separate entities. And in general the course is prepared on the assumption that the majority of students are never going to specialize in psychology and should consequently be given the most interesting and useful facts and principles of psychology, regardless of whether or not they are usually reserved for graduate students.

The course is conducted in a radically different way from that of prevailing courses. The student is immediately introduced to problems of behavior taken as a whole and only after he is fairly familiar with psychological procedure, terminology and point of

view is he given his psychological background. The even numbered lessons present problems to be solved and the odd numbered lessons supply in a general way answers to the problems, together with a broader interpretation of the facts than the average student will discover for himself. For example, Lesson 6 outlines the familiar mirror-drawing experiment. This is performed, say on Monday. That night the experiment is written up and handed in at the class-hour on Tuesday. That hour is devoted to a general discussion of what was discovered in the experiment on the learning process. At the close of the hour Section No. 3 is given the class containing Lessons 7 and 8. The class reads over Lesson 7 on Tuesday evening. At the next class-hour Lesson 8 is taken up in the laboratory in the same way as Lesson 6. Each topic is accordingly handled as follows: (1) The student performs an experiment illustrating the principle to be emphasized, (2) he solves the problem as best he can and hands in his report, (3) he has the benefit of a class discussion upon the subject at the next class-hour, (4) he reads over what the author has to say on the subject, (5) he receives back his own corrected paper on the subject; (6) he reviews the subject later on. All class discussion is based upon the laboratory experiences, not upon the author's presentation of the subject. The latter is only a supplementary aid, to correct misunderstandings and to furnish the student a standard by which to check his own work.

Individual differences are amply provided for in such a procedure. The poor student obtains a concrete grasp of the main points of the course. The able and industrious student adds to this minimum a very much broader and more detailed understanding of the whole subject. The rate of progression is such that even the ablest student realizes that he is not getting all that there is in the course. All are thereby stimulated in a way that is not true when the rate is slow enough to discuss thoroughly every detail mentioned in the text.

The text is printed as a book or in the form of 23 booklets. The advantage of the booklets is that they prevent the student reading ahead. This is important as the odd numbered lessons contain the answers to most of the problems. Where students read ahead they lose the training resulting from working problems out for themselves.

So many have been of general inspiration and help in this work that space will not permit special mention of their services. Several who have used the text in its mimeographed form have aided in a very definite way in revising and clarifying sections. They are: Miss Kate Anthony, State Normal School, Cape Girardeau, Mo.; Professor C. M. Faithful, Tennessee College, Murfreesboro, Tenn.; Professor S. C. Garrison, George Peabody College for Teachers; Professor W. A. McCall, Teachers' College, Columbia University, and Professor J. Roemer, Sam Houston Normal Institute, Huntsville, Texas. Professor Y. Shoninger, George Peabody College for Teachers, helped me very considerably in writing up the description of a "sight-spelling lesson." To all these I owe very much. But I owe most to my wife, for her constant encouragement and assistance in the preparation of this text.

The present revision and expansion of the original text has been made in the light of suggestions received from many instructors who have written me on the subject. Their interest is very gratefully recognized.

I desire also to express my appreciation for the courtesy of authors and publishers for permission to reproduce illustrations. I am indebted to The American Book Company for a figure from D. J. Hill's *The Elements of Psychology;* to Dr. S. A. Courtis and the Department of Education, University of Indiana, for a figure from the *Second Indiana Educational Conference Report;* to Dr. Courtis and The World Book Company, for figures from *Standard Practice Tests;* to Dean J. R. Angell and Henry Holt and Company for figures from *Psychology;* to Dr. J. D. Lickley and Longsmans, Green and Company, for a figure from *The Nervous System;* to Professor Wm. McDougall and John W. Luce Co. for special permission to quote from *Social Psychology;* to Harper & Bros. to quote from my *The Psychology of Selling Life Insurance;* to Dr. W. B. Pillsbury and The Macmillan Company for a figure from *Fundamentals of Psychology;* and to Dr. E. L. Thorndike for figures and several quotations from *Educational Psychology,* Vol. III.

Carnegie Institute of Technology,
June 1, 1922.

CONTENTS

INTRODUCTORY PSYCHOLOGY

LESSON 1

WHAT IS PSYCHOLOGY?[1]

Some of you are doubtless familiar with the story from which the following incident is quoted. But it bears repeating.

Sam had never told his love; he was, in fact, sensitive about it. This meeting with the lady was by chance, and although it afforded exquisite moments, his heart was beating in an unaccustomed manner, and he was suffering from embarrassment, being at a loss, also, for subjects of conversation. It is, indeed, no easy matter to chat easily with a person, however lovely and beloved, who keeps her face turned the other way, maintains one foot in rapid and continuous motion through an arc seemingly perilous to her equilibrium, and confines her responses, both affirmative and negative, to "U-huh."

Altogether, Sam was sufficiently nervous without any help from Penrod, and it was with pure horror that he heard his own name and Mabel's shrieked upon the ambient air with viperish insinuations.

"Sam-my and May-bul! Oh, Oh!"

Sam started violently. Mabel ceased to swing her foot, and both encarnadined, looked up and down and everywhere for the invisible but well-known owner of that voice. It came again, in taunting mockery.

"Sammy's mad, and I am glad,
And I know what will please him,
A bottle of wine to make him shine,
And Mabel Rorebeck to squeeze him!"

[1] The attention of instructors is called to a booklet of instructions in which suggestions are made as to assignments, necessary laboratory material, and procedure in some of the experiments.

"Fresh old thing!" said Miss Rorebeck, becoming articulate. And, unreasonably including Sam in her indignation, she tossed her head at him with an unmistakable effect of scorn. She began to walk away.

"Well, Mabel," said Sam plaintively, following, "it ain't my fault. I didn't do anything. It's Penrod."

"I don't care—" she began pettishly, when the viperish voice was again lifted.

> "Oh, oh, oh!
> Who's your beau?
> Guess I know:
> Mabel and Sammy, oh, oh, oh!
> I caught you!"

Then Mabel did one of those things which eternally perplex the slower sex. She deliberately made a face, not at the tree behind which Penrod was lurking but at the innocent and heart-wrung Sam. "You needn't come limpin' after me, Sam Williams!" she said, though Sam was approaching upon two perfectly sound legs. And then she ran away at the top of her speed.

"Run, nigger, run—" Penrod began inexcusably. But Sam cut the persecutions short at this point. Stung to fury, he charged upon the sheltering tree in the Schofields' yard.[1]

Why is it that this account is interesting to us? Why did Sam and Mabel enjoy being together? Why were they so nervous and uneasy? Why did Penrod call out as he did? Why did Mabel get mad at Sam? Why did she run away? Why did Sam get mad? What happened when Sam reached Penrod?

At this point some of my readers may stop and, with lifted eyebrows, question silently, "Is this a game of twenty questions? And twenty foolish questions at that? Can this be psychology?"

It is. All these questions are real psychological problems, quite as pertinent to the science of psychology as the dignified and dry-as-dust queries you doubtless expected.

What then is psychology?

In commencing any new course of study it is necessary to have some idea of what the whole thing is about. At the same time

[1] Booth Tarkington—*Penrod and Sam*, 1916, p. 220ff.

it is extremely difficult to obtain a clear notion since most of the details are unknown to the beginner. It is only after one has experienced details that he is in a position to understand any summary of them. Consequently the following definition is just to aid the reader in orienting himself. Only toward the end of the course will he be prepared to grasp its full meaning.

Psychology may best be defined as the science of behavior.

There is the definition. The matters dealt with in the next ten sections will give some of the various fields included in its bounds.

1. A crowd surrounded the automobile of Dr. John Linder yesterday, when the physician stopped at Glenmore and Vesta Avenues after a dog had dodged beneath the auto's wheels and had been killed. There were men and women in the throng and they seemed to think that the physician had not tried to avoid the dog.

Dr. Linder endeavored to explain that the most expert of motorists could not have dodged the dog, which ran barking beside the wheels of his auto and finally slipped under them. The crowd muttered angrily about motorists who had no thought for human lives, let alone the life of a dog, and Dr. Linder, realizing that the crowd soon might become dangerous, tried to start his car.

His action aroused several men in the crowd who had been working themselves into a fury, and one of them struck out at the doctor with his fist. The physician ducked, and reaching in his pocket, jerked out a glittering object of nickel which he thrust into his assailant's face, exclaiming:—

"Stand off. Get back from this car. I'll shoot the first man who interferes with me."

The man who had struck at the physician, with all the rest of the crowd, fell back hastily, and Dr. Linder, seizing the opportunity, applied the power to his car and slipped away. John Cargill, a blacksmith of the neighborhood, noted the number of of the doctor's car, however, and hurried to the New Jersey Avenue Court where he got a summons for the physician, calling on him to show cause why he shouldn't be punished for violation of the Sullivan Law against carrying weapons. The physician had scarcely arrived at his home when the summons was served and he hurried back to court in his automobile.

Cargill was present and Dr. Linder, after explaining the acci-

dent to Magistrate Naumer, declared that Cargill had been particularly aggressive.

"He had a mob at his back," said the doctor, "and I was really afraid they would attack me."

"But your revolver?" questioned Magistrate Naumer. "Do you not know that under the present law you may not carry a weapon without a permit?"

"Why, I only threatened the crowd with this," replied the physician as he pulling something from his pocket and snapped it into the Magistrate's face. There was a small report, and Magistrate Naumer clutched spasmodically at the desk in front of him. Then he burst into a laugh as he observed the glittering nickel cigar lighter which Dr. Linder held in his hand.

Dr. Linder would not make a charge against Cargill, and the smith hurried out of the courtroom to the accompaniment of laughter in which every one joined.[1]

Why should a crowd become angry because a dog had been killed? Would Cargill have become as angry if he had been alone as he did when surrounded by a crowd? Why did the crowd think Dr. Linder had a gun? Why did Cargill want the Doctor arrested? Why did the crowd in the courtroom all laugh at Cargill? Why have you also enjoyed Cargill's discomfiture?

2. A frequent sight is that of little boys fighting. Why do they like to fight? Why does a woman want to stop this fighting? Why will men pay half a million dollars to sit in the broiling sun and see a prize fight?

3. Consider any advertisement before you. What situation is depicted? Does it in any way express your feelings? Could the advertisement be changed so that it would present a situation that would make you really want the commodity advertised?

4. Consider the following cases:—

(1) A college professor discovers that a wealthy old bachelor keeps a large amount of money hidden in his house. After weeks of clever work he discovers where this money is kept and finally obtains a pass key. One night he enters the house, secures the money and on being discovered by the old man, kills him.

[1] New York Times, 1911.

(2) A young man by the name of Black from a prominent family is engaged to marry Miss Smith. Mr. Jones, although knowing of the engagement, deliberately makes love to Miss Smith and eventually supplants Black. When Black discovers the fact, in a fury of rage, he kills Jones.

(3) C is attacked by a burglar in his own home and after a struggle kills the burglar.

(4) D recklessly drives his auto through the streets of a village and kills a young boy.

(5) E attacks two little boys in the woods and after torturing them for some time, finally cuts one of them to pieces with a razor.

In these five cases a man has killed another human being. Each is a murderer. Why shouldn't all be hanged for their crime? Your answer, of course, is that the circumstances are different. Can we conclude that the five men are different sorts of men on the basis of the circumstances which are presented? How can we evaluate their conduct? in terms of their action, or in terms of the situations which confronted them, or in terms of both situation and response?

5. All respectable school teachers spend some time every year condemning prize fights, bull fights, gambling, drinking, etc. Especially is this true of women teachers. Yet two of my acquaintances when visiting the exposition at San Diego several years ago, rode down to Tia Juana, in Mexico, and very much enjoyed a prize fight, lost a quarter at each of the gambling tables in the "joint" there, and afterwards loudly berated their fate because they arrived too late for the bull-fight. Is it conceivable that the difference in the situations which confront them at home, in the school, or at Tia Juana, is responsible for strong condemnation of a prize fight in one place and attendance at and enjoyment of one in another place?

Do you think it possible to set down all the details making up the situation which confronts one and then to record the response made to this complex situation? If we knew all the details would we be able to prophesy what a person would do? Cannot I be certain that you will say to yourself "7" and then "cat" after reading the next two sentences? What does 3 and 4 make? What does c-a-t spell?

6. A man, walking with a friend in the neighborhood of a country village, suddenly expressed extreme irritation concerning the church bells, which happened to be pealing at the moment. He maintained that their tone was intrinsically unpleasant, their harmony ugly, and the total effect altogether disagreeable. The friend was astonished, for the bells in question were famous for their singular beauty. He endeavored, therefore, to elucidate the real cause underlying his companion's attitude. Skilful questioning elicited the further remark that not only were the bells unpleasant but that the clergyman of the church wrote extremely bad poetry. The causal "complex" was then apparent, for the man whose ears had been offended by the bells also wrote poetry, and in a recent criticism his work had been compared very unfavorably with that of the clergyman. The "rivalry-complex" thus engendered had expressed itself indirectly by an unjustifiable denunciation of the innocent church bells. The direct expression would, of course, have been abuse of the clergyman himself or of his works.

It will be observed that, without the subsequent analysis, the behavior of the man would have appeared inexplicable, or at best ascribable to "bad temper," "irritability," or some other not very satisfying reason. Most cases where sudden passion over some trifle is witnessed may be explained along similar lines, and demonstrated to be the effect of some other and quite adequate cause. The apparently incomprehensible reaction is then seen to be the natural resultant of perfectly definite antecedents.[1]

Did you ever "fly off the handle" at a perfectly innocent person? Have you ever ridiculed a person's clothes when the only trouble with the clothes was that the wearer had beaten you out in an examination? If your friends were aware of one or more of such complexes, as Hart has described above, would it help them in understanding your conduct? Would it help them to prophesy what you would do next?

7. Now I want to be a nice, accommodating patient; anything from sewing on a button, mending a net, or scrubbing the floor, or making a bed. I am a jack-of-all trades and master of none! (Laughs! notices nurse.) But I don't like women to wait on me

[1] B. Hart, *The Psychology of Insanity*, 1912, p. 73f.

when I am in bed; I am modest; this all goes because I want to get married again. Oh, I am quite a talker; I work for a New York talking machine company. You are a physician, but I don't think you are much of a lawyer, are you? I demand that you send for a lawyer. I want him to take evidence. By God in Heaven, my Saviour, I will make somebody sweat! I worked by the sweat of my brow. (Notices money on the table.) A quarter; twenty-five cents. IN GOD we trust; United States of America; Army and Navy Forever!"[1]

The preceding paragraph and the one that follows are verbatim copies of the remarks of two different individuals. The former is that of a maniac and illustrates what is called "flight of ideas;" the latter is that of a dementia præcox patient and illustrates "incoherent speech."

"What liver and bacon is I don't know. You are a spare; the spare; that's all. It is Aunt Mary. Is it Aunt Mary? Would you look at the thing? What would you think? Cold cream. That's all. Well, I thought a comediata. Don't worry about a comediata. You write, he is writing. Shouldn't write. That's all. I'll bet you have a lump on your back. That's all. I looked out the window and I didn't know what underground announcements are. My husband had to take dogs for a fit of sickness.[2]

Offhand one wouldn't say that there was any order or system to these two paragraphs, particularly the second one. And experts have more or less held that view until recently, when careful study commenced to show that there were rules and principles underlying even the ravings of the insane. Some day these will be as thoroughly understood as are physical and chemical laws today.

8. Beliefs have been held as peculiarly one's own, and so intangible that no one until recently has dreamed of measuring them. Yet below there are given nine beliefs making up a sort of scale extending from absolute belief (100) through doubt (0) to absolute disbelief (−100). This scale is very imperfect,

[1] J. R. deFursac, *op. cit.*, p. 72.

[2] J. R. deFursac, *Manual of Psychiatry*, translated by A. J. Rosanoff, 1908, p. 71.

being based on but a limited number of men and women, but it illustrates what can be done along the line of measuring intangible things.

2 plus 2 equals 4.	99
There exists an all wise Creator of the world	73
A house-fly has six feet	47
The most honest man I know will be honest ten years from now.	21
"Blessed are the meek for they shall inherit the earth."	− 2
Magna Charta was signed in 1512.	−22
"It never rains but it pours."	−53
"Only the good die young."	−74
2 plus 4 equals 7.	−99

If one wishes to determine, for example, how strongly he believes that "dark-haired girls are prettier than light-haired ones," he can compare it with those statements above and so obtain a rating for it. The writer cannot comprehend why the average man should rate this belief half way between the fifth and sixth beliefs on the "scale," and the average woman half-way between the sixth and seventh. But they do.

9. From the New York Times of about May 1, 1914, is quoted the following editorial comment on an article by a Superintendent of a Connecticut brass works which appeared in *The Iron Age*.

At these works there was recently constructed a long incline up which heavy loads were to be wheeled in barrows, and premiums were offered to the men who did or exceeded a certain amount of this labor. They attempted it vigorously, but none succeeded in earning any of the extra money, instead they all fell considerably below the fixed task.

Prompt investigation by an expert disclosed that the trouble lay in the fact that the men were working without sufficiently frequent periods of rest. Thereupon a foreman was stationed by a clock, and every twelve minutes he blew a whistle. At the sound every barrowman stopped where he was, sat down on his barrow, and rested for three minutes. The first hour after that was done showed a remarkable change for the better in accomplishment; the second day the men all made a premium allowance by doing

more than what had been too much; and on the third day the minimum compensation had risen, on the average, 40 per cent, with no complaints of overdriving from any of the force.

Apparently a man can do more physical labor by working 12 minutes and resting 3 minutes out of every 15 than he can if he works all of every 15 minute period throughout the day. This principle is one of the fundamental principles underlying scientific management, which has been so much discussed of late in various publications. Possibly this principle might be utilized by you in your daily life. But you may need to know considerably more of the whole subject before making the proper application of it to your particular type of work.

10. How long does it take to say the alphabet? And how much time is required for one to say it backwards? And having said it once will one be able to recite it faster on a second trial? In Plate I is shown graphically just how much time is required to recite the alphabet forwards (i. e., 6.0 seconds) and backwards (i. e., 46.0 seconds), and furthermore how much time is required for each successive recitation up to twenty times. An average adult will decrease his time from 6.0 to 4.0 seconds in the one case and from 46.0 to 12.5 seconds in the second case.

Why do we thus improve with practice? And how is the improvement accomplished? Where are the changes registered? Such a simple performance as that of saying the alphabet is after all very complicated. Watching a child mastering its intricacies gives us some little appreciation of this fact. Involved in this case are many of the problems of education—problems which are also fundamental psychological ones. We meet similar problems on every hand. Today a human being may be unable to use a typewriter, or swim, or dance, or play golf, or run a motor boat; he may know nothing about banking, or politics, or how to broil a steak, or make a cake, or trim a hat. Yet in a short time we may find he has acquired any or many of these performances. This is such a common occurrence we pay little attention to it. But the more we consider the matter the more we should marvel at it. How does a person learn to typewrite? How comes it that his fingers hit the right keys although his eyes are on the sheet from which he is copying? Or take

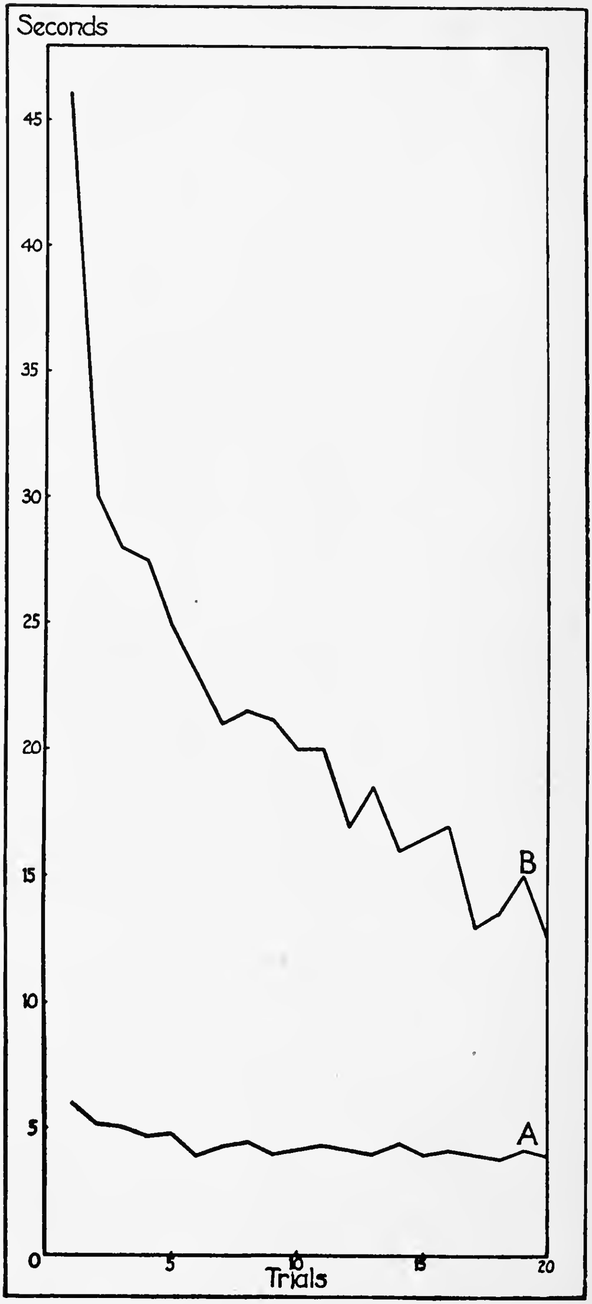


PLATE I.—Showing the time required (seconds) to recite the alphabet forwards (Curve A) and backwards (Curve B) for twenty successive trials. (Data based on the records of eight adults.)

another experience through which we have all gone. How have we come to know that 7 plus 6 is 13 or that 7 times 6 is 42? Have all persons learned these two performances in the same way? Is there one best way to learn them? If so, what is it? Why is it that some never can learn such things—for we have known boys and girls and even men and women who can't.

What has been given in this chapter could be extended indefinitely so as to bring in incidents dealing with the differences between whites and negroes or Chinese; problems dealing with poverty and its origin, or with success and its causes; questions concerning delinquency in court or truancy in school; methods of selecting salesmen for a great corporation or telephone girls for thetelephone co. In fact, it may be extended so as to include any and every relation that exists or may ever exist between man and man. All of these subjects may be discussed and many are discussed in other divisions of knowledge, such as history, economics, sociology, anthropology, psychiatry, criminology, advertising, salesmanship, education, etc., but all belong in the science of psychology.

Psychology has been defined as the *science of behavior*. It is concerned with the orderly presentation of the facts and laws which underlie human conduct. It not only includes this but also takes in the whole realm of living beings. Today psychologists are not only studying how man behaves and how he learns but also how rats, and guinea pigs, and monkeys, and birds, and even earthworms, behave and how they learn. This work with animals may seem foolish but it has already led to a better understanding of many phases of human behavior and undoubtedly will lead to very much more.

Psychology has not always been defined in this way. In earlier days it was defined as the "science of the soul" or the "science of mind." Both of these definitions led to insurmountable difficulties and have been discarded. A third definition, i. e., "psychology is the science of consciousness," is still held by many psychologists. With such a definition one is led to emphasize conscious acts and more particularly the content of consciousness to the exclusion of such phenomena as are popularly grouped under the headings of behavior and conduct. But of late, the definition upheld in this book has been adopted by more and more psychologists.

And the field of psychology is being deliberately broadened so that it shall include all of man's activity of every sort and kind. At the present time it is quite clear that those who uphold the definition of psychology as the science of consciousness are little or not at all interested in applied psychology, while those who have espoused the definition of psychology as the science of behavior are also those who have been most active in the application of psychology to advertising, salesmanship, vocational guidance, medical and legal problems, etc.

Such a great subject as man's behavior cannot be covered in a few pages or in a few weeks. A beginning course must commence at some point and develop it in a systematic manner. This means that only certain things can be considered here. What shall those things be? Primarily, we shall consider how man learns. This will lead into many related phases of man's conduct and, of course, if quite thorough would sooner or later touch all of man's behavior. But to attempt such a complete investigation would be too tremendous an undertaking. We shall have to be content with a general survey of the learning process with special reference to learning in the school. We shall take up one example after another; we shall actually learn things in order to have fresh in our minds just how it feels to learn; we shall compare our progress with that of others in order to see how individuals differ; and we shall compare one performance with another in order to draw up general principles and laws which will explain what learning is and how it is accomplished.

After considering some of the principles underlying the way in which man learns and how men differ, particularly in learning, we shall consider third what men want, or, in other words, why men act as they do. As a corollary we shall further consider how one may get another to do as he desires. The applications throughout will be to the problems of education, but many will be taken from other fields of activity in order to illustrate the common relationship to be found among all of man's activities.

LESSON 2

COMPONENTS OF BEHAVIOR

Human behavior is very complicated. Because it is so, the usual practice in commencing its study is to consider examples that have been artificially made simple. There are advantages in such a procedure, but the writer believes that there are even more disadvantages. What is wanted here is that the student shall deduce his psychological principles from everyday experiences and so be able to use what psychology he possesses at all times. Consequently an actual lesson in *sight-spelling*, as it is called, taken from a first grade in the grammar school, will be used as an illustration of certain fundamental psychological principles.

The Sight-Spelling Lesson

The sight-spelling lesson is employed by many teachers in the elementary school to train children in spelling. It consists essentially of showing a word for a moment and then requiring the child to reproduce the word in writing. It is one of the methods used in training pupils to read words, and even sentences, before they know their letters.

Relationship of a Sight-spelling Lesson to Lessons in Reading and Writing.—In order to get the right setting for the understanding of a sight-spelling lesson it will be necessary to go back and get clearly in mind just what a teacher has attempted to accomplish before commencing the teaching of spelling. This preliminary work as given in a typical school can be roughly divided into four steps:

First. The children relate their experience in class.—Day after day the children are encouraged and led to talk about things that interest them.

Second. These experiences are written on the board.—On a Monday about three weeks after the opening of school, the children are asked for example, to tell their experiences since

last Friday. One little boy may reply as follows, his sentences being written on the board as he gives them:—

"I went to the country on Saturday.

"I played with Fred.

"We played leapfrog.

"We played ball.

"We had a happy time."

The children are here given a clear conception of the fact that what they say may be recorded on the board—that writing has something to do with their very thoughts.

Third. Drill is commenced leading to "recognition" of the sentences, phrases and words.—The teacher asks: "Who can find where it says, 'I went to the country on Saturday'? . . . Who can find where it says, 'We played leapfrog'? . . . Where does it say, 'We played ball'? . . . Where does it say, 'I played with Fred'?" etc. At first these sentences are remembered largely because of their *position* on the board. The child remembers the order in which the sentences occurred and makes his guesses accordingly. Soon, however, the recognitions are made in terms of the *form* of the whole sentence.

Right from the start whole sentences or phrases or words are thus drilled upon. Slowly for some children, more quickly for others, the forms of the words or sentences are remembered and connected with their sound. As the word is pronounced by the teacher and then pointed to by some child, the teacher rewrites the word and calls their attention to the fact that "This (pointing to the written word) always says 'ball.'" After three or four days of such work in which the question has been all the time, "where is this," the children are ready for the fourth step.

Fourth. Drill is given leading to "recall" of the sentences, phrases and words.—Here the characteristic question is, "What does this say?" The child here must verbally reproduce from memory the words and sentences as the teacher points to the written symbols. Here again, as the words are pointed to and then named by the child, the teacher frequently rewrites the word (for example, "ball") at the side of the sentence and says, "This always says ball."

At this point writing may be introduced to the child. The teacher choosing some particular word, asks the children to watch her write it. The children watch the word as it is written

and after it has been erased go to the board and write it as best they can.

The fourth step is really two steps—one deals with the recall of the sound of the word when it is seen (reading); the other deals with the reproduction of the form of the word after it is seen (writing). The former means that the child will properly move the muscles of his speech organs when confronted by the sight of the word; the other that he will properly move the muscles of his fingers and arm when confronted by the sound of the word.

In a diagrammatic way we can illustrate these two processes as follows:—

Reading.	Seeing word "ball"	saying the word "ball."
Writing.	Seeing word "ball"	writing the word "ball."
Writing.	Hearing the word "ball"	writing the word "ball."

The method of developing the second part of this process of "recall" is called "sight-spelling." It might more properly be called "sight-writing," for the emphasis in the drill is upon a reproduction of the form of a word previously seen, but not now present to sight.

The Sight-spelling Lesson in Detail.—The procedure in a sight-spelling lesson is as follows: The teacher pronounces the word "ball," then writes it on the board at the usual rate of writing, then pronounces the word "ball" again, allows the children to look at it for a moment, and erases it. Then she tells them that she is going to call upon them to go to the board and write the word there. She then rewrites the word, pronouncing it as she does so, and may have the class also pronounce it.. After they have looked at it for a moment, she erases it. Then one or more children are sent to the board to write the word. Some of the children may get it correctly while others will fail. Those who have failed may be given one or more chances to see the word written again or not as the teacher is disposed. Then another word is presented and the procedure is repeated. (One of the most important elements in the whole process is the matter of having the child watch the teacher as she writes the word. It is not enough for the child to see the completed word, *he must see it as it is written.* Otherwise, he may attempt to write it backwards or in some other way than the correct method.)

As this drill is continued each child learns how best to utilize

his time while the word is exposed on the board so as to be able to write the word later. These methods which children adopt have not been worked out by adults as yet. When they are understood in all probability we shall be able to help the child develop the best method for him. What actually takes place, no matter how it is done, is that the child sees the word written on the board and then after it is erased goes to the board and reproduces the form of the word as he has previously seen it. (Of course it is not meant that the reproduction is anything but an approximation at first, but with practice there results a fairly good imitation of the teacher's form.)

Summary.—The above paragraphs have presented (1) what a sight-spelling lesson is, (2) the relationship between a sight-spelling lesson and other lessons in the first grade which have led up to it and (3) the detailed elements in a sight-spelling lesson. We now have a general idea of the relationship of spelling to conversation (oral expression), reading and writing.

The Three Components of Behavior—Situation, Bond and Response[1]

At this stage in the course it will be impossible to discuss in detail the various steps relating to the sight-spelling lesson or to work out the various psychological principles involved in any one step. To do so properly would necessitate a fairly complete knowledge of psychology—the very thing we, of course, do not have at our disposal just now.

For the present it will be sufficient to get clearly in mind one big conception which the following three questions and their answers will present.

What is the Object of the Lesson?—Evidently, to teach the children how to spell the words presented. Or possibly a better answer is—to arrange matters so that the children will learn the spelling of certain words. Consequently, every detail in the whole lesson (every act or idea of teacher or child) is related to this central proposition "the child learning." (And conversely, if there is any detail which does not actually aid the child to learn, it is out of place.)

[1] Of the three components mentioned here, the first and third alone will be discussed in this lession; the "bond" will be taken up in the following lesson.

How May All the Details in the Entire Lesson be Divided into Two Groups as They Relate to the Child's Learning?—On the one hand the child *sees and hears* certain things; that is, the child is influenced by certain things and, on the other hand, the child *does* certain things. All the actions of the teacher, whether spoken words, written words, or gestures—all influence the child. Likewise, all the actions of other children in the room influence the child. And because of all this the child makes certain responses. Obviously then the details in any lesson fall into the two groups, (1) those which influence the child, and (2) those which constitute the child's reaction.

How May We Designate these Two Groups of Details Which Make Up the Spelling Lesson?—All those details of the lesson which go to influence the child, all combined together, we may call the *Situation.* And all those details which constitute what the child does, we may call the *Response.*

To illustrate these two terms, take this single incident in a spelling lesson. Following a discussion of a "leaf" and the writing of sentences on the board concerning a leaf the teacher then turns to the matter of teaching the writing of the single word. She turns and writes the word "leaf" on the board. Pointing to the word on the board, she announces, "This is the word 'leaf.'" Then she erases the word. "Now I am going to write the word 'leaf' again on the board. I want you to watch carefully and see how I do it. After I have written it on the board, I am going to erase it. Then I am going to ask you to come to the board and write it."

The *Situation* confronting any child, for example, Carl, and his *Response* can diagrammatically be expressed as follows:

Situation	Response
1. Carl in school. 2. Presence of teacher and schoolmates. 3. Preceding events concerning a "leaf." 4. Teacher's instructions about noticing the word on the board and then reproducing it after she has erased her writing.	General state of attention (*a*) to class, (*b*) to teacher, and (*c*) to specific topic under discussion.

The teacher next goes on to say, "Now look carefully and get a good picture of 'leaf.'" She then writes the word on the board,

waits a moment, and then erases it. Then she calls on Carl to write the word on the board. Carl goes to the board and writes the word in his crude style of handwriting.

The situation confronting Carl and his response are:

Situation	Response
1, 2, 3, and 4 above (*continued*). 5. Teacher writes the word "leaf" on the board. 6. Teacher erases word. 7. Teacher calls on Carl to write word on board.	(*d*) Carl rises from seat, (*e*) walks to board, (*f*) writes word "leaf" on board, and (*g*) returns to his seat.

Because Carl has done well the teacher nods her approval. This can be represented in the same way:

Situation	Response
1, 2, and 7 (*continued*). 8. Carl's "leaf" on board. 9. Teacher nods her approval of his performance.	(*h*) Carl feels pleased.

It is evident that the *Situation* comprises the details which influence Carl in any way, while it is also evident that the *Response* comprises all the details of Carl's behavior in responding to the situation. It is equally evident that the Situation and the Response are very complicated, being made up of many details.

The first point to get in this course is that the learning process can be and must be resolved into the two factors "Situation" and "Response." All learning is the doing of something (Response) because of the influence exerted by certain other things (Situation).

Assignment to be Prepared for the Next Class-hour

1. Be prepared to give the steps in a sight-spelling lesson, distinguishing particularly between the "recognition" and "recall" processes.

2. Be prepared to discuss this lesson in terms of the two components—situation and response.

3. Write out your analysis of Sam's behavior as given in the quotations from *Penrod and Sam* on page 1. In order to handle such material in the easiest manner it is best to break the

story up into very short "scenes." (Thus the incident about Carl, above, was divided into three scenes.)

The first four scenes would be expressed diagrammatically as follows:

Situations Confronting Sam	Responses of Sam
1. Sam in love with Mabel.	(*a*) Stops and talks with Mabel.
2. Meets Mabel on the street.	
1, 2 (*continued*).	(*b*) Leans against the picket fence.
3. Mabel "keeps her face turned away," "maintains one foot in continuous motion," "confines her remarks to 'U-huh.' "	(*c*) Experiences "exquisite moments;" "heart beating in an unaccustomed manner;" "suffering from embarrassment."
	(*d*) Continues talking although his "usual habits of talking are interfered with, due to presence of unusual feelings," etc.
1, 2, 3 (*continued*).	
4. Unusual feelings in stomach, heart, lungs, etc.	(*e*) Further arousal of sex instinct.
5. Continues talking.	
1, 2, 3, 4, 5 (*continued*).	(*f*) Starts violently, blushes.
6. Penrod's, "Sam-my and Maybul! Oh, oh!"	(*g*) Looks for Penrod.

Finish the analysis of this passage. Be sure to write out your analysis, since by so doing you are forced to think definitely and clearly.[1]

[1] From author's *Psychology of Selling Life Insurance*, 1922, p. 63ff.

LESSON 3

COMPONENTS OF BEHAVIOR (continued)

In Lesson 2, we found that all the details in any lesson may be divided under the two heads, situation and response. Just to strengthen our grasp on this fact let us prove it in another case. We will take the method of teaching reading as given in Lesson 2, and consider not the behavior of a single person but the general principles underlying the behavior of all learners.

Since language is the *sine qua non* of reading we may say that the earliest steps in such learning are taken before the child's first birthday. A probable situation is the entrance of the father and the mother's statement, "Here comes dadda." If the baby happens to make a noise immediately thereupon, which approximates in any way the word "dadda," it will be greeted with wild enthusiasm by the parents, which will arouse the interest and pleasure of the baby. All of the baby's accidental successes will be so delightfully welcomed; his inopportune remarks ignored. After many such occurrences, the presence of the father and the sound of the word "dadda" will practically always cause the baby to say "dadda." After still more practice the sight of the father will in itself be sufficient to cause the baby to call him by name. For the situation has become linked to its appropriate response in the baby's mind.

Many words are learned in like manner. The vocal organs are increasingly exercised by crying, cooing, laughing and chance expressions, until the child has gained the ability to make all the sounds in the language. After this the vocabulary grows rapidly and names can be repeated after one or two hearings.

In all cases we have first the presence of the object and the sound of the name calling up the pronunciation of the name. After this is acquired the mere presence of the object is sufficient to induce the response of the word. Later the physical presence of the object is unnecessary. The ability to express ideas, desires, etc., develops.

Before the child begins to read, then, it has already learned that spoken words stand for visible objects. He has now to learn that visible words stand for spoken words, that there can be two situations leading to the same response.

The object, a flag	equals spoken "flag."
The word "flag"	equals spoken "flag."

The ability to pronounce the word when one sees it in written form is fundamentally the ability to read. (Of course, the reading of a well-trained person involves much more than pronouncing one word at a time in response to its written form. Smooth reading with expression is due to the development of these fundamental processes so that they operate smoothly and automatically together with the development of other habits dealing with expression and the like.)

What the teacher must do then is to form a connection, or *bond*, between this situation (the word "flag") and the desired response (saying "flag"). This is what she does in the method outlined in Lesson 2, i. e.,

1. Writes sentences on board.
2. Asks for recognition.
3. Demands recall.

This, it is clear, on a little consideration is the wise course of procedure. For at first the child has no response at all to the written words, "We have a big flag." The white chalk marks on the board mean nothing to the child. They mean, indeed, much less to the child than Chinese symbols do to you, the reader, for the child does not even know that they stand for spoken words—for objects and actions. But the teacher writes the words, "We have a big flag" on the board and pronounces the sentence to the class. Thus a weak link is formed between the sight of the whole sentence and its sound.

Then the child is asked to pick the sentence out from others. This is not so difficult as recalling it would be. We all know it is easier to recognize a face as having been seen before than to give the name belonging to the face. Even a faint connection between situation and response will lead to recognition.

And, of course, every such recognition strengthens the connection. After some drill the teacher can successfully ask what would have been useless before, that is, that the child recall·

what a given sentence says; i. e., respond to the question, "What does this say?" pointing at the same time to the written sentence. With recall the last step is reached and only more drill is needed. Then the child can read.

Reading is then at bottom, the moving of the muscles of the throat in response to certain curlicues on a page or blackboard. The proper control of these muscles is learned before school age. The joining them up with the new situation, the curlicues, is the task of the teacher of reading.

The object of a school lesson seems then to be the formation of a *bond* between a given situation and a desired response. An approved primary method is so constituted that it leads naturally from a stage in which there is no bond, through a stage where there is a slight bond, finally to a stage where a fairly strong bond is established and made stronger by drill.

Situation, Bond, and Response

Just how a human being behaves depends upon two factors—upon the elements confronting him in his environment and upon his own internal make-up. If we know what these external elements are and what the internal organization of the individual is, we can prophesy what he will do in response to any particular situation. For example, we know that all educated people can add and spell; consequently, we can safely depend upon it that any educated Englishman or American will think "four," and then "cat," as he reads the next line:

$2 + 2 =$ c-a-t

In the same way we know, if a boy and girl are interested in each other, that when they meet they will show embarrassment, excitement, etc. If they don't show these evidences of emotion they are not interested in each other. And we all know that a boy gets angry when called names, or caught with a girl he likes, or interfered with when he is with that girl. Knowing these things, we can prophesy a fight when Penrod provokes Sam.

There is absolutely nothing profound or complicated in this psychological analysis. We all know these facts and to a very considerable extent act upon them. For example, what happens when a circle of girls suspect one of their number of being engaged? They suddenly confront her with situations that should

make her blush or show embarrassment if she is engaged. And they determine whether she is guilty or not, not by what she says, but by the tone of her voice and her manner. For words we can fairly easily control, but not the tone of voice or manner.

Analysis of Behavior.—Suppose that without noticing what I am doing I put my hand on a hot radiator. The next moment I jerk it off, of course. Here we have the simplest kind of behavior. The hot radiator stimulated nerve endings in the skin of my hand, nervous current flowed over the sensory nerve to the spinal cord, from there it was directed out over motor nerves to the muscles of my arm, they contracted and jerked my hand away. All this would happen in just the same way were I asleep or awake; in other words consciousness is not involved. Later on I may be conscious or not, depending upon circumstances. The elements involved in all this are:

1. Hot radiator in contact with skin.
2. Sense-organs (nerve-endings) in skin aroused by heat.
3. Nerve current to nerve center.
4. Nerve current through nerve center.
5. Nerve current from nerve center to muscles.
6. Contraction of muscles (hand pulled away).

Before attempting to see what this means, consider a second example of behavior. Upon seeing "$2 + 2 =$ " I instantly think "4." Here the following elements are involved:

1. "$2 + 2 =$ "
2. Sense organ of sight (eye) stimulated.
3. Nervous current from retina of eye to brain.
4. Nervous current through brain (nerve-centers).
5. Nervous current from brain to muscles.
6. Contraction of muscles in throat (for when I think "4" the muscles of the throat move).

In addition there is:

7. Consciousness of (*a*) seeing "$2 + 2 =$ " and (*b*) thinking "4." (No one knows what relationship exists between "7. Consciousness" and "4. Nervous current through brain nerve-centers," but apparently consciousness is present only when such nerve-centers are aroused.

Analysis of one more example of behavior, which is slightly more complicated, will aid in making our point clear. John is asked by his teacher "If you had a quarter and bought four apples

at four cents each, how much money would you have left?" Here the elements are:

1. Problem presented by teacher to John in school.
2. Sense-organs of hearing and sight stimulated.
3. Nervous current to brain.
4. Nervous current through brain.
5. Nervous current from brain to muscles.
6. Contraction of muscles, saying "nine cents."
7. Consciousness of:
   (*a*) being in school, in arithmetic class, of being called upon by teacher, etc.
   (*b*) problem.
   (*c*) thinking 4×4.
   (*d*) thinking 16.
   (*e*) thinking $25 - 16$.
   (*f*) thinking 9.

Here we have quite a complicated lot of factors. They could be made to appear still more complicated if they were subdivided into still finer divisions.

One Way of Grouping Elements.—These elements can be grouped roughly under the three headings of situation, bond, and response, so that all the elements that affect the individual are put under the heading of situation; all the elements that are involved in the result are put under the heading of response; and the connection between situation and response is classed as bond. When so grouped we should have:

Situation	Bond	Response
1. Problem, etc. 2. Sense-organ aroused. 3. Nervous current to brain. 7. Consciousness of: (*a*) being in school, etc. (*b*) problem.	4. Nervous current through brain.	5. Nervous current to muscles. 6. Muscular contractions. 7. Consciousness of: (*e–f*) thinking out solution.

The *situation* will always be used in the practical sense of including (*a*) objects arousing sense-organs to activity, and (*b*) presence[1] of all other elements in mind at the time. For example,

[1] Strictly speaking, the very general term "presence" must be used and not "consciousness" because one responds to elements that are present but not necessarily conscious, as, for example, restlessness and listlessness as responses to a slight fever not consciously realized.

in the story of Penrod and Sam, Mabel is an object which stimulates Sam's eye, he becomes conscious of her, and at the same time is conscious of his interest in her. All these together cause him to stop and talk to her.

The response will always be used in the practical sense of including (*a*) muscular movements, (*b*) change in activity of glands (e. g., flow of saliva upon seeing a well-cooked beefsteak) and other physiological changes within the body (e. g., heart beating faster) and (*c*) consciousness of result from responding to situation (e. g., answer to problem, satisfaction at getting it correct, etc.).

The bond will always refer to the connection between situation and response—a connection to be thought of as a pathway made up of nerve-cells and a pathway over which current passes when the situation occurs.

Situations are Ordinarily Complex.—When you read "2 + 2 =" you are confronted with a very simple situation. But when Sam replied to Mabel by saying, "Well, Mabel, it ain't my fault. I didn't do anything. It's Penrod," he was responding to a very complex situation. It involved his love for Mabel, her presence, his unnatural feelings and emotions, the presence of Penrod, Penrod's remarks, Mabel's reactions to Penrod shown in her remarks to Sam and her walking away. But these were only a beginning. Such other factors were involved as, Sam's being born a boy, a certain number of years before, with definite hereditary tendencies; his having grown up in a rough-and-ready boy society. Eliminate any one of these elements of the total situation confronting Sam and his response would be different.

Can an item be both a response and a situation?—The analysis of the passage from *Penrod and Sam* has undoubtedly puzzled many, in that certain items were listed in one "scene" as responses and then in the next "scene" as situations. For example, one response on the part of Sam on meeting Mabel was "exquisite moments," "heart beating in an unaccustomed manner," "suffering from embarrassment." These phenomena resulted from meeting her. But they in turn immediately commenced to affect his further behavior. Thus the wildly beating heart and irregular breathing interfered with his talking. In the same way the response of thinking out the answer "nine cents" to the problem analyzed above can be broken up into scenes

to show that as each element in the response occurs it immediately joins with all the other elements in the situation to cause the next response.

Behavior is a steady stream of events. In analyzing it we have to break it up into short scenes in order to discuss it. In doing so we do violence to some of the facts. But if we bear in mind that the scenes are artificial units of behavior, that behavior is flowing along, and that details from without first make some impression and then very often these responses in turn join with the next details from without as causes for the next impression, we shall not go far astray in our study.

A Second Way of Grouping Elements Entering into Behavior.—At times it is very helpful for clear thinking to distinguish between the object in the situation and the conscious elements present in the mind at the time. The term "*stimulus*" (plural stimuli) will accordingly be used to refer solely to the external object stimulating a sense-organ.

There is no corresponding term which covers the muscular and glandular response to stimulation and does not include the conscious elements of response. But when the formula stimulus-bond-response is employed, the term response should be interpreted in the narrower sense, whereas when the formula situation-bond-response is used, the term response should be interpreted in the broader sense.

This double way of dividing behavior into its components is very troublesome to beginning students in psychology. As the course progresses the matter will gradually become clearer and clearer; particularly so, if the student will keep clearly in mind that when situation-bond-response occurs the emphasis is being put upon cause and effect, whereas when stimulus-bond-response occurs, emphasis is being put strictly upon the factors outside the individual as they affect him. And in such cases the elements within his brain are to be thought of as due to systems of nerve-cells that have been aroused to activity—hence are to be viewed as part of the bond.

Further Consideration of the Term "Bond."—The term "bond" conveys the meaning of *connecting* situation and response. Instead of "bond" the term "mechanism" could be employed, so calling to mind a *system of nerve cells that operates as a unit.* And again, instead of "bond" the term "experience" could be

used, thus emphasizing that the individual is acting in terms of his own *experience*, or that of the race, born in him. When "bond" is used all three of these conceptions should be thought of. The response follows the situation because a mechanism has been set into operation connecting the two together and this connection represents the experience of the past.

Scientific Conception of Behavior

The teacher (and most of us do more or less teaching during our lives) needs to realize that his task is to so present stimuli that a situation will confront the child which will lead to the desired response. This means the teacher must acquire a fund of knowledge and experience so as to know the psychological connections between situations and responses. Such knowledge will help in two ways: first, it will enable the teacher to present the right stimuli and second, it will cause the teacher immediately to look for the presence of unsuspected elements in a situation when the desired response does not result. For example, a boy was transferred from one school to another and at the bottom of the transfer was written, "George is a good boy and gets his lessons well." The new teacher stuck the transfer on a hook on the wall where it was seen by the children in the room. George had been a good boy in the sixth grade, but no situation that the seventh grade teacher could devise would cause good behavior because he was always reacting to the jibes of his fellows about being a good boy. Lack of knowledge of how a twelve-year-old boy must respond to the situation "good boy" from his playmates caused this teacher a "heap" of unnecessary trouble.

Summary

Two principal points have been presented so far. First, the nature of psychology and what psychologists are attempting to do, and second, that behavior can be viewed in terms of the three components—situation, bond, and response.

Object of Lessons 4 to 18

In the next fifteen lessons an analytical study of the learning process will be made. Very simple tasks of learning will be assigned and careful observations of how each task is accom-

plished will make many of the fundamental principles of learning apparent.

The next class-hour will be devoted to such an experiment. Before coming to class, read over the instructions in Lesson 4 up to the heading: "Instructions for writing up the results." *But do not practice the experiment.* If you do, you are quite likely to get results at the next class-hour that will be misleading and extremely difficult to write up.

LESSON 4

HOW DOES ONE LEARN TO SAY THE ALPHABET?

The first laboratory assignment in a new course of study must necessarily be very simple, else the beginning student will be swamped with all the details confronting him. Consequently, we shall study here what is apparently a simple problem, i. e., the processes involved in learning the alphabet—particularly in learning to say it backwards. But although the assignment in one sense is very simple, yet in another sense it is most profound. No one can list all the processes that are involved here nor understand any of them absolutely.

The student commencing this course should carry with him much of the spirit of the early pioneer. He is starting on a journey of exploration in which some of the landmarks are known and mapped for him but most of the smaller points of interest are not mapped and still remain to be discovered. This course in educational psychology will afford every student opportunities for discovering facts and principles regarding the learning process not now recorded in any textbook. Consequently he may attack this seemingly trivial assignment in the spirit of exploration and with the determination to discover new things.

1. Problem.—What happens when you recite (1) the alphabet forwards twenty times, and (2) the alphabet backwards twenty times?

2. Apparatus.—A watch with a second hand. (If you do not have such a watch, obtain one from the instructor.)

3. Procedure.—Two persons will work together; one will be the *Subject* (person to do the reciting) and one will be the *Experimenter.* When both are ready the Experimenter will watch the second hand and when it reaches 58 on the dial will call out, "Get ready," and when it reaches 60 will say "Go." The Subject will then recite the alphabet as fast as possible. When the Subject reaches the letter "Z" the Experimenter notes the number of seconds that have elapsed and records it in his notes.

The Experimenter will find it necessary to have before him the alphabet written out so that as the Subject recites he may follow with his eye and note any mistakes in the Subject's recitation.

After each of the 20 trials, the Experimenter should record (*a*) the time required by the Subject to recite the alphabet, (*b*) any mistakes in doing so, (*c*) any changes in method he may note, (*d*) any other interesting facts.

Having finished the above, repeat the whole procedure but this time recite the alphabet backwards, instead of forwards. The Experimenter should write out the alphabet backwards in order to aid him in catching the mistakes of the Subject. The Experimenter will not prompt the Subject except to say, "No," when the Subject gives a wrong letter.

As before, the Experimenter will record (*a*) the time required by the Subject to recite the alphabet backwards, (*b*) any mistakes in doing so, (*c*) any changes in method, (*d*) any other interesting facts.

(Finish the above before reading further.)

Instructions for Writing up the Experiment

If possible both partners should arrange to prepare the assignment together. If this is not possible, then the Subject should secure a copy of the Experimenter's notes. Both should prepare this assignment and hand it in at the next class-hour.

How to Plot a Learning Curve.—Refer to the curves shown in Plate I, as a model. The curves of no two persons are alike, consequently yours will not agree exactly with the two given in Lesson 1.

Plot the data you have secured in the two parts of the experiment. Do as follows: Secure a sheet of co-ordinate paper. Draw a line across the bottom of the sheet about a half inch from the bottom. Draw another line at right angles to this base line along the left-hand side of the sheet, about a half inch from the edge of the paper. At intervals of about one-fourth inch number consecutively from 1 to 20 underneath the base line. Number the lines along the vertical line consecutively from 1 up as far as the paper permits. Call the base line "0."

The numbering along the base line represents the successive trials from 1 to 20. The numbering along the vertical axis

represents the amount of time consumed in reciting the alphabet. Hence at the right of the figure 20 write the word "Trials" and at the top of the page above the last number in the vertical scale, write the word "Seconds."

When this is done, note the time-record in the first recitation of the alphabet. Suppose this is 6 seconds. Now mark a small "x" at the intersection of the line numbered "6 seconds" and the line numbered "trial 1." Suppose the second trial was done in 5 seconds. Then mark similarly a small "x" at the intersection of the 5-second line and the 2d-trial line. (If it was 5½ seconds, instead of 5, the cross would be made half-way between the 6-second and the 5-second line.) When you have marked the twenty "x's," then connect them together withs traight lines. This jagged line represents the *learning curve* in saying the alphabet forwards. Draw the learning curve for saying the alphabet backwards in the same way.

Give a *title to the sheet*, such as "Learning Curves for Reciting the Alphabet Forwards and Backwards."

How to Write up the Experiment.—1. *The problem.*—State what is the problem you are attempting to solve. In this case the problem may be stated as "How Does One Learn to Say the Alphabet?"

2. *Apparatus.*—State under this heading what apparatus you used in solving the problem, as "A watch with a second hand."

3. *Procedure.*—State what you did in order to secure your results. Give date and names of the Experimenter and Subject, first of all. In this course you need not copy the procedure as given in the text but may state, "Followed instructions as given in manual, except ——." Then give in detail any deviations.

4. *Results.*—Here record (1) your time records, (2) mistakes made, (3) changes in method, (4) other interesting facts, (5) your curves. In other words, record under this heading the material you have gathered together in performing the experiment.

5. *Interpretation.*—Here ordinarily you would summarize your results and explain what they mean. At the beginning of this course you will be aided in interpreting your results by being given specific questions to answer—questions which help you summarize and explain your results. In this case, answer the following questions:

(*a*) How do your two learning curves differ? Explain why.

(*b*) In what respects do the two curves agree? Explain.

(*c*) Why is it possible to recite the alphabet faster and with fewer mistakes on the twentieth trial than on the first trial? Has the Situation changed? Has the Response changed? Or has the Bond changed?

(*d*) Why do you suppose in Lesson 3, Carl could write the word "leaf" on the board after having seen his teacher write it and not before? What changed there—the situation, the response, or the bond?

6. *Applications.*—Record concrete cases where principles developed here will apply in other phases of life. For example, in learning to use a saw, one will saw through a 6-inch plank very slowly the first time and will do a pretty poor job. Next time the job will be done in less time and with fewer ragged edges. Successive trials will result in better and better work. The greatest progress will be made in the early trials.

In this lesson you have been confronted with several things, which were probably new to you, such as:—

1. Saying the alphabet backwards.
2. A learning curve and its characteristics.
3. Plotting a curve.
4. Writing up a laboratory experiment according to a prescribed outline.

It will require a number of further lessons before the last three of these propositions will become thoroughly established. Apply what you have learned in this experiment to yourself. It will take time to write up this experiment and you will not do it without many mistakes. A month from now you will have cut your time in half and you will not make those mistakes. Do the best you can in the time you have for preparing the lesson.

LESSON 5

SOME FACTS CONCERNING THE LEARNING PROCESS AS OBTAINED FROM THE ALPHABET EXPERIMENT

All learning is dependent upon practice, upon performing what is to be learned. That is the way you originally learned to say the alphabet forwards and that is the only way you can learn to say it backwards.

In like manner you must yourself work out the assignments of the course. And to the extent that you do actually answer the questions, to just that extent you have a real grasp of the contents of the course.

In order to afford you a check upon your work so that you may know how well you are doing it, the odd-numbered lessons (e. g., lessons 5, 7, 9, etc.) will answer the problems raised in the even-numbered lessons (e. g., lessons 4, 6, 8, etc.). These answers are not complete answers; no one knows enough today to answer absolutely completely. But they will furnish sufficiently complete answers for the purpose of the course.

It goes without saying that you will lose the full value of the course if you refer to the odd-numbered lessons before handing in your written reports upon the corresponding even-numbered lessons.

Answers to Questions in Lesson 4

How Do Your Two Learning Curves Differ? Explain Why.—(1) The "saying alphabet forwards" curve drops very little, whereas the other curve drops a great deal. That is, there is very little improvement in the first case and a great deal in the second.

2. The curve in the first case is practically a straight line (disregarding now the irregular fluctuations) while the curve in the second case shows a very great drop at first with less and less of a drop as the trials continue.

3. The second curve is throughout "higher" than the first curve.

Explanation. The learning curve of a performance that

has not been practised, shows a big drop after each trial, but as the trials continue, the curve drops less and less until it finally reaches a certain limit. In the case of saying the alphabet forwards we must realize that the early trials (with their resulting big drops) have occurred long ago. We are dealing possibly with trials 1001 to 1020 and can expect only very slight improvement from trial to trial. In fact we must be fairly near the limit of speed that can be obtained in this performance.

The chief difference between the two curves is to be explained by the fact that the first curve is the only portion we have of a learning curve made up of, say, a thousand and twenty repetitions, whereas the second curve is actually representative of the beginning of a learning process. The first curve must needs be nearly a straight line with only a slight drop, while the second curve must needs show large drops between each successive trial, but smaller and smaller drops as the repetitions continue. If we kept up the reciting of the alphabet backwards 10 times a day for a month or more possibly we would then get a curve on the last day that would be similar to our first curve.

From the shape of the curve we can then tell something as to the amount of training which has already preceded the first trial shown in the curve.

In What Respects Do the Two Curves Agree? Explain.—(1) Both drop. Both show improvement in the work done.

Explanation. A fundamental law of human behavior is the only explanation that can be given for the fact that both curves drop. Continued repetition of a performance results in that performance becoming easier and easier and when there is any effort made to decrease the time of doing it, the performance is done in less and less time.

2. Both show fluctuations. Improvement is not always shown between successive trials. Sometimes the performance is much inferior to that of several preceding trials.

Explanation. The performance of any act is made up of many parts. Learning the whole performance (e. g., saying the alphabet backwards) consists in learning to do each little part and in learning to do them in the correct order. Sometimes the parts are all fairly well done—then we make a better record than usual—there is a sudden drop in the curve. Sometimes the parts are done poorly—then we make a poorer record than

usual—there is an upward shoot to the curve. Most of the time we do some parts well and some poorly—then we make an average record.

The causes as to why any part is done poorly or well will be taken up later. (Commence watching for them. Note why you fumble in tying your shoes, putting on your hat, shaving, spreading butter on a slice of bread, misspelling a word, answering a question incorrectly in an examination, etc.)

In What Respects Do the Situations and Responses Differ at the Beginning and End of the Two Experiments? Explain Why.—(This question is inserted in addition to those asked in Lesson 4.)

As to situation.

1. Certain details were added to the situation. Certain details affected the Subject more and more, e. g.—
   (*a*) Certain combinations of letters are difficult (e. g., w, v, u, t.) and so are watched with more than ordinary care.
   (*b*) Letters said at first more or less one at a time, later become grouped—groups thus take the place of single letters as the items which affect the subject.
   (*c*) The ideas, "I must go fast," "I must not make mistakes," impress the subject more and more.
2. Certain details were eliminated more or less from the situation, e. g.—
   (*a*) Strangeness of surroundings ceased to affect the Subject.
   (*b*) Strangeness of requirement—to recite alphabet in psychology class—was forgotten.
   (*c*) Presence of other individuals, their conversation, etc. became less noticeable.
   (*d*) Presence of the Experimenter, the fact that he was watching, the fact that he was taking notes, the fact that he was timing, etc., had less effect.

In other words, as learning progressed, the situation actually changed. Certain details affected the Subject more and more and certain other details less and less.

As to response

1. Actual performance was done (*a*) more quickly, (*b*) with fewer mistakes, (*c*) more smoothly.

2. Feelings of strangeness, unfamiliarity, nervousness, excitement, unpleasantness, etc., became changed more or less to feelings of familiarity, confidence and pleasantness, etc.
3. Actual method of doing work was changed, particularly in saying alphabet backwards, e. g.—
   (*a*) At first alphabet had to be recited forwards in order to say it backwards; later this became unnecessary.
   (*b*) It was recited in short pieces with pauses in between.
   (*c*) Pauses became shorter, groupings of letters longer and longer.
   (*d*) Etc.

The process of learning involves then not simply doing work faster and faster with fewer and fewer mistakes, but also attention to different details in the situation coupled with qualitative changes in method (The above changes in both situations and response are actually due very largely to changes in the bond. From practice there results a better and better co-ordination and functioning of neural path-ways and the elimination of other path-ways that interfere with the work in hand. As explained in Lesson 3, these changes can be referred, however, to the situation or response.)

Why is it possible to recite the alphabet faster and with fewer mistakes on the twentieth trial than on the first trial? Has the situation changed? Has the response changed? Or has the bond changed?

The first part of this question has been answered under the second question, above.

Has the situation changed? In one sense, No. There are the same factors outside the learner at the twentieth trial that were there at the first trial. But in another sense, Yes. In some way or other the learner has changed, so that he is influenced less by certain of the outside factors and more by other outside factors. Actually from the standpoint of the learner, then, the situation has changed, he is affected by details in a different way from what he was at the start.

Has the response changed? Undoubtedly. This is shown by the decrease in time and the increase in accuracy, also by the change in attitude toward the task.

What other changes have there been? We shall come to see

that the bond or mechanism within the learner that is affected by outside factors and that controls the learner's muscles (for all behavior is composed of muscular movements) has been changed by the repetition of the alphabet.

We may think of this nervous mechanism as having been changed, on the one hand, so that now in this particular situation it is more susceptible to certain details and less susceptible to other details, and on the other hand, that it controls and directs the muscles engaged in speaking differently from what it did at the start. The learner is certainly more susceptible to the difficulties of reciting "w, v, u, t" than at the start. He is also less concerned with the presence of his partner than at the start, and undoubtedly does recite the alphabet backwards in a much better manner than at the start. His behavior is different. His response to the situation is different.

Learning to say the alphabet backwards comprises a certain situation, a certain response and a bond between the two. At the start this bond is very imperfectly developed. As repetition continues, the bond is developed until finally the situation (Experimenter says, "recite the alphabet backwards") is adequately bound to the various muscular movements which cause the letters of the alphabet to be sounded.

Let us look upon the multiplication table in this same way. The teacher asks, "What is 6 times 8?" The child responds "48." The situation, in terms of the child, is (1) the teacher, (2) the sounds making up "What is 6 times 8?" Certain muscles in the throat and mouth move and the child has said "48." Connecting the ear and the throat muscles are various nerve-centers and nerve-fibres. The stimulation in the ear has been communicated in a wonderful way over these nerve-pathways to the muscles in the throat and they have been moved—and "48" is said. The terms, "Situation," "Bond," and "Response," may be thought of now as covering this whole learned performance.

Why do you suppose Carl in Lesson 2 could write the word "leaf" on the board after seeing his teacher write it and not before? What changed there—the situation, the response or the bond?

If Carl has learned to write the word without knowing his letters, then the sight of the word and sound of the word have

both become bound up with the movements of making the word. While Carl looked at the word and while he listened to the sound of the word, he wrote the word in the air, i. e., made the movements necessary to write the word. Diagrammatically, we have

Sight of word ⟶ Movements involved in writing word.
Sound of word ⟶ Movements involved in writing word.

Through previous training in school and outside Carl had learned how to trace a drawing. Hence when he saw the word he was able to trace the word in the air. After a sufficient number of repetitions the bond connecting this situation with this response became strong enough to function. But the possession of a bond between *seeing* the word "leaf" and writing it was not enough, else Carl could not write the word when his teacher *pronounced* it. While Carl was looking at the word he was also muttering it to himself. The teacher was also pronouncing it. Hearing the word then was part of the situation. And while hearing it he was also writing it in the air. Repetition of this detail of the situation and the response shortly resulted in a bond being formed between hearing the word and writing it.

To answer the question, we must reply that a bond was formed between sight of the word "leaf" and the movements necessary to write it, also a bond between hearing the word and writing it. There has been a development of new bonds and consequently a new response. Before there was no bond and hence no writing response to the word "leaf." Afterwards there is a bond and so an appropriate response is possible.

It should be borne in mind that the above analysis is not so full as it should be. And it should further be borne in mind that this analysis may be true of some children and not true of others. We do not know today just how all children come to do these things. Some details will be added as this course develops.

Summary of Points Covered So Far in This Course

1. Analysis of sight-spelling lesson.
2. Understanding of the terms, "Situation," "Bond," and "Response."
3. Realization that a situation is a complex affair made up of many details and a response is correspondingly complex.
4. Method of plotting a learning curve.
5. The fact that repetition of the same performance produces

changes in the real situation, in the response, and in the bonds connecting situation with response.

6. Some characteristics of learning curves.
7. A method of writing up a laboratory exercise, involving the classification of your material under six headings:—
   (*a*) The Problem, what you are trying to do.
   (*b*) The Apparatus, what you have to work with.
   (*c*) The Procedure, how you go at solving the problem.
   (*d*) The Results, what information you discover.
   (*e*) The Interpretation, what you decide the results mean.
   (*f*) The Application, how the general principles outlined under "Interpretation" can be applied to other problems.

Some Information Concerning the Construction of Curves

1. All learning curves are based on two columns of data. The first column indicates the successive trials or successive units of time in terms of which the progress of learning is measured. The second column gives the measurements of the learning. For example, the data on which Curve B in Plate I is based are as follows:

Trials	Number of Seconds Required to Recite the Alphabet Backwards
1	46.0
2	30.1
3	28.4
4	27.8
5	25.1
6	22.9
7	21.0
8	21.8
9	21.2
10	20.1
11	20.2
12	16.9
13	18.2
14	16.0
15	15.3
16	15.6
17	13.6
18	13.9
19	15.5
20	12.5

2. The trials are indicated along the horizontal axis and the "measurements of the learning" along the vertical axis.

3. Figures for the horizontal scale should always be placed at the bottom of the chart and the figures for the vertical scale at the left. Make clear what the scales mean.

4. In the curves in the psychological field, the horizontal scale should read from left to right and the vertical scale from bottom to top.

5. All lettering and all figures on a chart should be placed so as to be read from the base or from the right-hand edge of the chart.

6. Points on the curve should be indicated with little crosses (x) and connected with a line that is heavier than the co-ordinate ruling so that the curves may be clearly distinguished from the background.

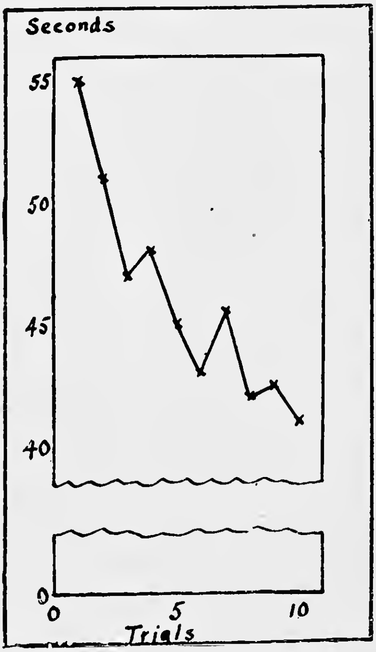


PLATE II.—Model graph, showing how zero base line should be indicated when there would not otherwise be space available to include the base line.

7. Only in exceptional cases should the zero line of the scale be omitted. If it would require too much space to include the zero base line, the bottom should be a slightly wavy line indicating that the field has been broken off and does not reach to zero. This is shown in the accompanying graph, Plate II.

8. The title of a chart should be so complete and so clear that misinterpretation will be impossible. In fact, the ideal is to write so definitely that if a stranger picked up the chart he could understand what it meant.[1]

[1] Good references on this subject for those interested in the subject are: W. C. Brinton, *Graphic Methods for Presenting Facts,* 1914 and C. Alexander, *School Statistics and Publicity,* 1919.

LESSON 6

HOW DOES ONE IMPROVE IN MIRROR-DRAWING?

In Lessons 4 and 5 we obtained some idea of the process by which one learns an alphabet. The same general principles will apply more or less to the learning of lists of things, such as conjugations, declensions, etc.

Today we are interested in discovering the general characteristics of the learning process in such cases as learning to write with a pen, to ride a bicycle, to skate, to use a saw, etc. As adults are all able to write it is manifestly impossible to study with adult subjects the learning processes involved in handwriting. For that reason the experiment will be devoted to learning to draw while looking in a mirror. This process involves many factors which are common to learning handwriting. Endeavor as best you can to understand this learning process as it will help you to understand what a child experiences while learning.

As before, one partner will act as Experimenter (E) and the other as Subject (S). Here the emphasis will be upon completing the drawing of 17 stars in the mirror-drawing apparatus. This can only be done by prompt and efficient effort.

The Mirror-Drawing Experiment

Problem.—How does one improve as one learns to draw in the Mirror-Drawing apparatus?

Apparatus.—Mirror-Drawing Outfit; 17 six-pointed star blanks, watch.

Procedure.—1. The Experimenter determines how long it takes the Subject to trace the outline of the star, *without using the mirror*. Let him start at the point marked in the star and draw naturally around within the two lines.

2. Experimenter arranges the apparatus so that Subject can

not see his own hand directly, but only through the mirror. Subject is to trace the outline of the star as quickly as possible with a lead pencil.

The requirement is that the pencil *must stay on the paper,* and must pass in order around the star. Measure the time required to pass around the star. Then record the number of times the pencil line touches either of the two printed lines. Each one should be counted a mistake. Furthermore, when the pencil is outside of the two printed lines, each change in direction should also be counted as one mistake.

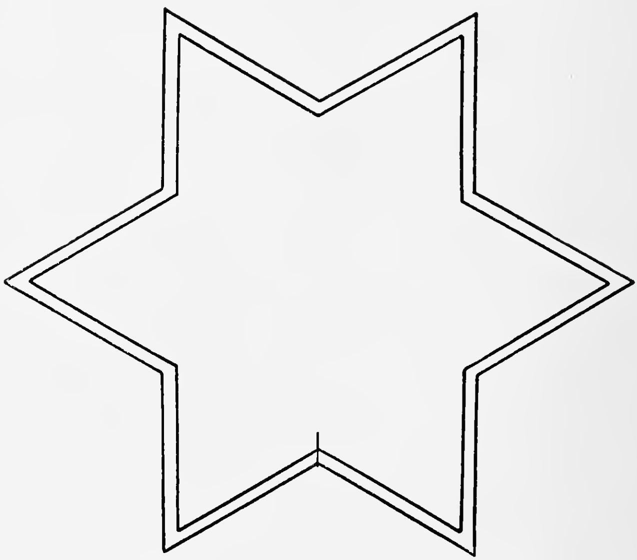


PLATE III.—Star blank for mirror-drawing experiment. (Actual size 4¼ × 5 inches.)

The star should be so placed that the starting point is towards S as he sees it in the mirror. If now each point is numbered from 1 to 12 (12 being at the starting and ending point and 1 at the point to S's right as he sees it in the mirror), it will be found to make the matter of writing up the laboratory notes much easier, for all places on the star can thus be easily referred to.

3. Have S trace 14 more stars in the mirror-drawing apparatus, making a total of 15 in all. Obtain the time for each trial.

Be sure to write on each star blank the number of the trial and the name of the Subject, also the time consumed in doing the drawing. Otherwise a gust of wind may mix up your papers and ruin your experiment.

4. Have S trace another star as he did in (1) without the use of the mirror.

This provides for the use of 17 star blanks; 2 are used without the mirror and 15 with the mirror.

Results.—E should have recorded then, (1) the time of each performance, and (2) the number of false moves to be observed by counting the number of times the lead pencil touches or crosses a printed line, and the changes in direction when without the printed line.

The learning curves. Plot both the time-records and the accuracy-records. Provide on the base line space for 17 trials; on the vertical axis space for recording up to 300 seconds. (You can do this by letting each horizontal line represent 5 or 10 seconds.) Remember trials 1 and 17 were made without the mirror; trials 2 to 16, with the mirror. Do not connect trial 1 with 2 or 16 with 17. Connect trial 2 with 3 with 4, etc., up to 16, using a solid line; and trial 1 with 17 using a dotted line.

Next plot the accuracy-records. For the sake of convenience consider each error equivalent to a second in time and plot accordingly. Finally plot a third curve obtained by adding together the seconds taken to do the trials with the number of errors. This curve will represent the course of learning, taking into account both time and accuracy combined.

Both partners will write up the report according to the outline given in Lesson 4. The *Results* will include the material (*data*) gathered together during the experiment and also the three learning curves.

Interpretation.—Under this heading note answers to the following questions:

1. What changes take place when the same performance is repeated a number of times? Consider (*a*) speed, (*b*) accuracy, and (*c*) the two combined.

2. What light do the data secured when the mirror is not used throw upon the main results of this experiment? In other words, how efficiently do you suppose the Subject could come to do the mirror-drawing after a great deal of practice?

Applications.—Do not fail to report some *concrete* examples of how the principles discovered in the experiment can be applied to your own work.

NOTES: (1) The word "data" is plural always.

(2) As you are studying the learning process it is absolutely essential that S shall not practice in any way whatever between trials, else your data will not be complete. If a trial is performed and the time-record is lost, report this fact. For example, if the time-record for the 12th trial was lost, call it nevertheless the 12th trial, and the next trial the 13th. In plotting, simply connect the 11th and 13th records with a dotted line, to indicate that the 12th record is missing.

LESSON 7

GENERAL CHARACTERISTICS OF THE LEARNING PROCESS

Answers to the Questions in Lesson 6

What changes take place when the same performance is repeated a number of times? Consider (a) speed, (b) accuracy, and (c) the two combined.

The first drawing with the right hand in the mirror was done very slowly and with many mistakes. The second drawing was very much better, there being a noticeable decrease both in the time consumed and the number of mistakes made. With each subsequent trial there was improvement (barring certain exceptions) until with the last trial we have a drawing made in very much less time and with few errors. In Plate IV we have three learning curves showing 20 trials (not 15) and based on the average of 18 records from men and women. Both curves A (accuracy) and B (speed) show rapid improvement at the start with smaller and smaller gains as the practice continues. The combined curve (C) shows the same peculiarities.

From studying curves B and C it is apparent that if these 18 individuals had continued the practice for more than 20 trials they would have improved still more. Curve A, on the other hand, suggests that they had reached their limit in accuracy; in fact, that they had reached this limit by about the 8th trial. (Trials 12 and 18 are actually the most accurate.) There is, however, another possible explanation. The instruction given the individuals whose average data we have before us, was purposely left indefinite as to whether *speed* or *accuracy* should be striven for. Their reports show, however, that most of them had in mind doing the task as quickly as possible, with a fair degree of accuracy, rather than doing the task as accurately as possible with a fair degree of speed. Consequently, the time curve shows the greater amount of improvement. It

is extremely likely then that the accuracy shown in Curve A from the 8th to 20th trials represents to these individuals "a

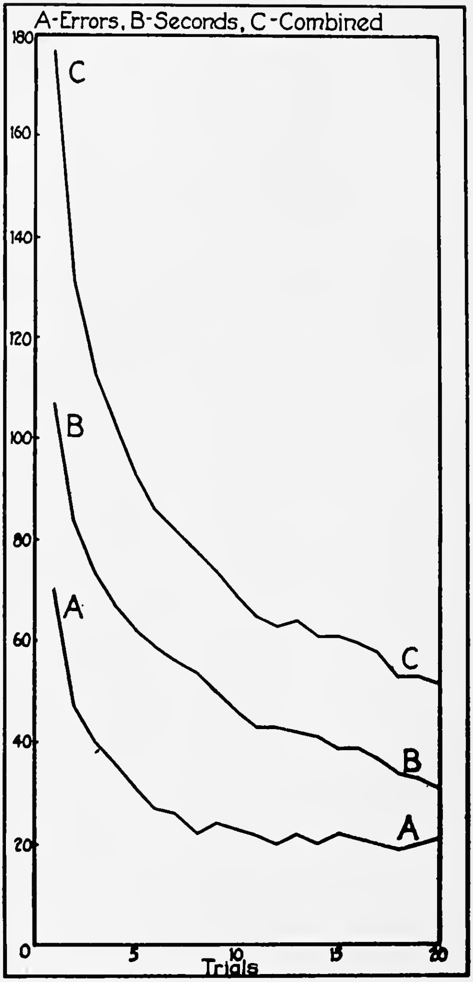


PLATE IV.—Curves showing progress of learning to draw while looking in a mirror.

Curve A records errors made per trial. Curve B records time (in seconds) consumed per trial. Curve C records total errors and seconds per trial.

fair degree of accuracy"—that during those trials there was little or no attempt to improve their accuracy. If this be true, further practice would eventually bring each subject to a point

where he would realize that his accuracy-record was not so good as it might be as compared with his time-record. His general attitude toward the work would change then so that he would strive for accuracy in a way that he had not done previously. Following this change in attitude there would undoubtedly appear a series of drops in the accuracy-curve with possibly little or no improvement in the time-curve. Judging then from what we can learn from the observations of our subjects, they have not reached their limit of improvement in accuracy, but rather only a temporary limit, this temporary limit being due to their attitude toward the work.

Such temporary limits are called *plateaus* or level places in a learning curve. In terms of what little we now know from this course about plateaus, we may define them as "temporary limits to improvement." In terms of our three components Situation, Bond, and Response, we may say that certain details in the situation are not affecting the learner as they should. Because they are not, there is little or no response to them and hence no improvement in the bonds connecting those details in the situation with their appropriate details in the response. Later these details commence to affect the learner, the bonds between those details and their responses commence to be used and improvement follows. At least this was apparently the case here. The little irregularities in the drawn line together with various memories which make up our notion of accuracy, all these were not affecting the learner so strongly as they might. As these details were being reacted to only a little or not at all there was little or no chance for the bonds to be developed. Later these same details would commence to affect the learner and then there would come improvement in accuracy. We shall then need to add to our previous conceptions of a learning curve—rapid improvement at first with less and less improvement as time goes on—this notion of a *plateau.* Improvement may cease entirely, certainly as far as objective proof is concerned, for a period of time and then commence again.

The plateau may be looked upon as a peculiar kind of fluctuation or deviation from the true course of learning. It is a deviation which extends over a number of trials. The most common form of deviation is that which occurs very frequently in practically all learning curves and consists in sudden up or down

deviations from the general trend of the curve. In Plate IV, Curve A, we have such downward fluctuations at the 8th, 12th, 14th, etc., trials, and an upward fluctuation at the 7th trial. But these fluctuations are much less frequent and much less prominent in Plate IV than they are in curves plotted from the data of just one individual. These fluctuations from trial to trial have already been referred to in Lesson 5, where an explanation of their cause is given.

What light do the data secured when the mirror is not used throw upon the main result of this experiment?

The data secured when the mirror is not used give us a clear idea of just how fast and accurately the subject can do the drawing without the mirror. The efficiency shown measures the strength of the old bonds formed in drawing, writing, etc., which function here. There is no reason to suppose that with sufficient practice the subject could not reach this efficiency under the new experimental condition. These data then give us some idea of the possible limit to the learning curve obtained in our twenty trials. But it is true that further practice without the mirror would lead one to draw the star in less time and more accurately. Consequently even this determination obtained without the mirror is not low enough for the final limit that might be reached by a vast amount of practice in the mirror. The final limit that an individual might reach with unlimited practice is called the *physiological limit* to the learning. It means that the physiological processes involved in the performance require a certain time and that when one reaches this limit one cannot progress further. It is extremely unlikely that the ordinary individual ever reaches his physiological limit in more than a very few simple processes which he has practiced vigorously a great many times. In most things we are very far from the limit. The world's record of 9⅗ seconds for the 100 yard dash represents the physiological limit of the best sprinter. Few, however, have ever reached their limit in this performance.

The plateau, referred to above, may be thought of, then, as a *temporary limit* in distinction to the *physiological limit* which is the final permanent limit of progress.

What applications can you make of the principles you have discovered to your own work?

One of the greatest needs today in our educational work is to

provide adequate means of registering the daily improvement of the students. If one can see himself improving he becomes very much interested and consequently does very much better work. The use of such curves as employed here enables a child not only to race against others but to race against himself. If he loafs, his curve shows it very clearly; if he works very hard, the curve registers that fact. Ordinarily only the superior children can obtain the thrill of winning in a scholastic race as school work is usually administered. But with the use of learning curves a dull child at the bottom of the class may experience the feeling of victory when he sees his curve rise. The presence or absence of a feeling of confidence in oneself may account for many of the successes or failures in life.

As an example of just how a learning curve may be used to great advantage the following case supplied by Martha Carroll is of interest.

"After a year and a half of unsuccessful attempts to stimulate anything worthy of the name of effort in an eleven year old boy pupil, I decided to make an attempt at a learning curve of some sort. The subject being music (and violin at that) it seemed almost an impossibility to figure out a method by which a record might be kept and exact progress noted. As an exact record of progress made, the curve (see Plate V) is a failure, but it accomplished its purpose of stimulating an effort.

"The lessons were 45 minute periods once a week—30 minutes being devoted (approximately) to the lesson assigned the previous week and 15 minutes to the new lesson. The record was kept during the period of assigned lesson only, any errors in the new lesson being left uncounted.

"The understanding with the pupil was, that for every correction I must make during the 30 minute period a mark would be made—these marks to be counted and stand for the grade at the end of the lesson. It was also agreed that no error noticed, and corrected by the pupil should be counted against him. The errors were to include those of position, intonation and rhythm—accuracy being the sole end in view.

"At the first lesson where the record was kept I made 40 corrections during the 30 minutes. For the first time, the child became aware of the fact that he did not 'know everything about it,' and that he was *not* 'doing it right.' He became intensely interested,

and from then on watched like a hawk every mark made against him and was very soon seeing his own mistakes and correcting them before I had a chance to do so.

"The first record was made on Feb. 22, 1916, and on May 23, 1916, the final record was made; the score having been reduced from 40 errors to 5 at the lowest record—and closing with a score

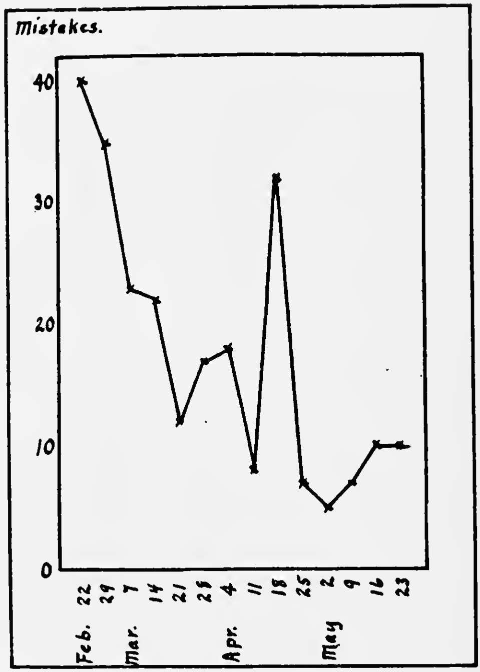


Plate V.—Curve showing progress in eliminating errors in learning to play the violin.

of 10 errors. That the actual amount of progress made is not evident, may be seen from the fact that at the time of the last record fully 3 1-3 times as much ground was covered in the 30 minutes as at the time of the first record, thus reducing considerably the percentage of errors at the final record.

"The change was entirely one of attitude, for the amount of actual practice time spent between lessons was *not* increased.

"The sudden rise in the curve at the ninth record I attribute to a return of the original attitude of self-satisfaction."[1]

Knowledge as to how fast a child of a certain age could possibly add columns of figures (physiological limit) would be helpful in handling him, especially when his work shows that he is on a plateau. By this we do not mean that our ideal is to have a child even approximately attain his physiological limit. Far from it. But it would help keep us from fearing to overstrain the boy when what he needs is to be urged to do his best.

Kate Anthony reports a case of an exceedingly bright boy who was but 9 years old but had been advanced to the 6th Grade. He stood at the head of his class in all matters of originality, initiative, and clear thinking but near the bottom in speed of handwriting, in drawing, and manual work. She believed his inability to do these latter performances as well as the average member of the class was due to his immaturity. An 11 or 12 year old boy is physically stronger and more dexterous than a 9 year old boy, just because he is two or three years older. And this difference is great enough so that a 9 year old bright boy is seriously handicapped in competing with an average 12 year old. If Anthony's conception is correct, i. e., that her 9 year old boy was doing poor work in manual training just because he was too young, then there was no need of worry about his poor performance. He was doing as well as could be expected of a 9 year old, although it was not 6th Grade work. But if she is wrong and he did poor work because he was not interested or not gifted along these lines, then extra effort should be put forth to get him to do better. An exact knowledge of what different aged boys could do and what they naturally do in manual training would help her here in determining how to handle him.

Mary McGahey found it impossible to improve Carl's arithmetic work as to speed. He was a 6th Grade pupil and did good work but did not solve simple arithmetical problems as fast as he should. The fact that McGahey knew that his rate of work was much below what an average boy could do made her realize that Carl was on a plateau which was far from being his physio-

[1] A very good example of how such methods have been utilized in industrial work is recorded by R. B. Wolf in *The Creative Workman*, published by the Technical Association of the Pulp and Paper Industry. See also, J. Q. O'Brien, *Silent Reading*, 1921, for extensive use of this device in teaching.

logical limit. This made her realize that something was wrong and that it "was up to her" to find it. Finally she noticed that he tapped twice before commencing to solve the simple combinations as

$$\begin{array}{r}4\\2\\\hline\end{array},\quad \begin{array}{r}8\\3\\\hline\end{array},\quad \begin{array}{r}7\\1\\\hline\end{array},\quad \begin{array}{r}4\\0\\\hline\end{array},$$

etc. On calling his attention to the matter and then reproving him every time he did tap, she quickly broke him of the habit. As a result he increased his rate of work 50% in a few hours' time. If McGahey had not known (1) what a child of Carl's age ought to do and (2) that he was making no progress, she would probably have never discovered the tapping and so never have trained him to do arithmetic problems at an efficient rate. (The tapping is undoubtedly a survival of an earlier habit of counting by making dashes on paper, instead of with one's fingers. Apparently Carl on finishing writing 6 as the answer of $\begin{array}{c}4\\2\\\hline\end{array}$ had to tap twice before commencing to think what $\begin{array}{c}8\\3\\\hline\end{array}$ meant. Under such a method he had pretty nearly reached his physiological limit. When the tapping was eliminated he was able to think the answer 11 to $\begin{array}{c}8\\3\\\hline\end{array}$ while writing the 6 and so could write continuously the answers to these problems, working out the answers ahead of where he was writing.)[1]

In Plates VI and VII are given the learning curves of four children (C, D, G, and H) when tested with simple addition and multiplication combinations. (The test blanks are shown on pages 152 and 153.) The records show how many combinations were performed correctly in one minute on fifteen different days. C gained twelve problems in addition in eight days and D the same number in five days, both completing the blank of eighty combinations in two minutes. G, on the other hand,

[1] Kate Anthony, Mary L. McGahey, Edward K. Strong, Jr. The Development of Proper Attitudes Toward School Work. *School and Society*, Dec. 25, 1915, p. 926ff.

gained but two problems in fifteen days and H none in the same time. In multiplication C gained twenty-four problems; D, twenty-four problems (in fourteen days), G, nine problems, and H, sixteen problems.

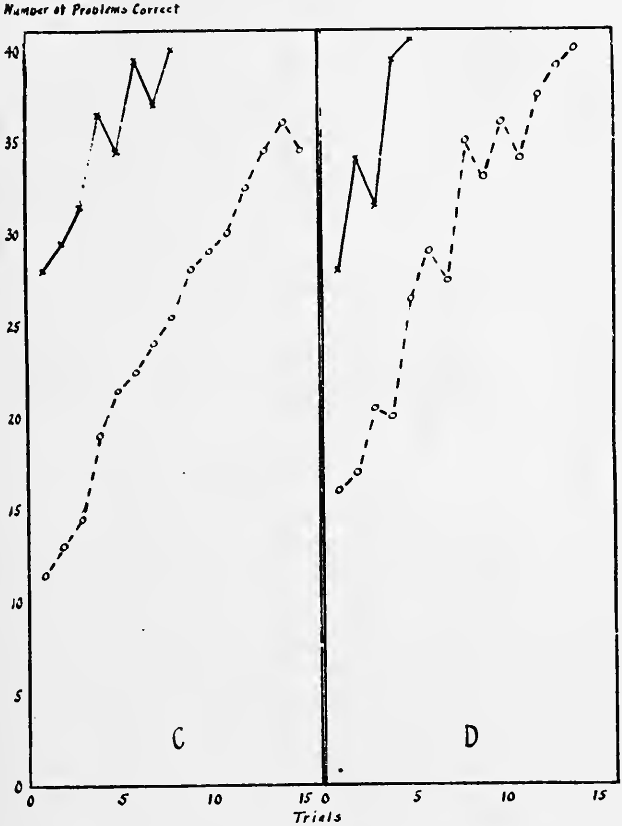


Plate VI.—Learning curves of C and D in simple addition (shown by the solid line) and multiplication (shown by the broken line).

Learning curves such as produced by C and D are typical of bright capable children while those curves produced by G and H are typical of children who stand near the bottom of their class. The curves of G are the poorest from the point of initial score or slope. This child never belonged in the 4th Grade and so dropped out of the school as there was no room for him in the

3rd Grade. His curves show markedly inferior knowledge of addition and multiplication and that he cannot learn rapidly. In fact he learns more slowly than other children in the same grade. There is then no chance of his catching up with his class. Instead he is going to be left farther and farther behind.

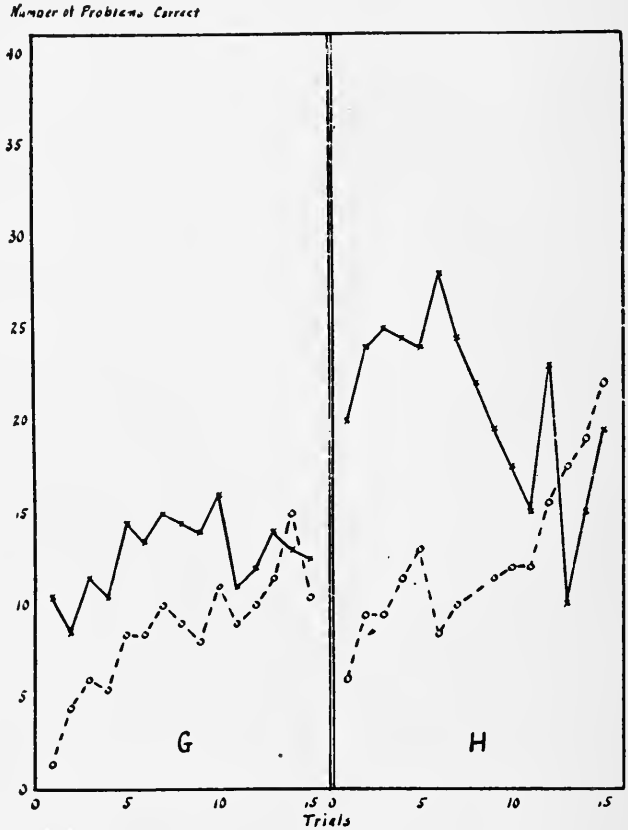


PLATE VII.—Learning curves of G and H in simple addition (shown by the solid line) and multiplication (shown by the broken line).

H's addition curve is very striking and unusual. As she improved in multiplication she lost in addition. In this instance there was a clear ease of *interference*, i. e., the habit of "seeing 4 × 3 and thinking 12" was interfering with the habit of "seeing 4 + 3 and thinking 7." She continued in this condition for some time afterwards. Later in the year she was put through

another practice series. The addition again showed an interference effect from the multiplication. In time she overcame this interference and eventually after three months of individual drill reached a speed of 40 problems in one minute in both addition and multiplication and a good speed in subtraction and column addition. But she has shown no ability to solve ordinary problems in arithmetic. A year later she was given these tests again. Her records were excellent, showing she had retained most of what she had learned. But her performance in more complicated arithmetic work was extremely poor. She never succeeded in solving problems requiring any original thinking.

LESSON 8

RELATIONSHIP OF METHOD, ATTITUDE AND FEELING TO LEARNING

Some of the more obvious laws of learning have been presented. We are now ready to attempt a more careful study of less apparent factors.

What happens when we change our method of doing a certain task—say of playing golf, of going from the sight to touch method in typewriting, or discovering a new way to solve originals in geometry? Do our feelings affect our work? We think they do: but do they really do so? Does the man that is confident do better than the man that is fearful? If so, why?

MIRROR-DRAWING EXPERIMENT (repeated)

Problem.—What factors are involved in learning Mirror-Drawing?

Apparatus.—Mirror-Drawing Outfit; 10 six-pointed star blanks; watch.

Procedure.—E should here be the S of the 6th class-hour and S the E of that exercise. Follow the general procedure of the 6th class-hour, but here S should only draw with the right hand in the mirror.

The emphasis is *not upon completing* 10 drawings *but upon obtaining as detailed an idea* of how one learns as is possible. Consequently after each drawing, S should note down every fact that occurs to him regarding his method of doing the work, the ideas that came to him while doing the drawing, his attitude toward the work, his feelings, etc. E should also record changes in *method* which he notes in S, changes in *feeling* or *attitude* toward the work, etc. Note down, for example, every sigh or exclamation of impatience, and ascertain if there is any relation between its occurrence and success or failure.

Results.—E should have recorded, (1) the time of each performance, (2) the number of errors in each drawing, and (3) the observations of both S and E accompanying each performance.

Draw three curves as in the 6th class-hour experiment.

Questions.—(1) What changes take place when the same performance is repeated a number of times? Consider (*a*) differences in method or "mode of attack," (*b*) differences in attitude toward the work, (*c*) differences in feeling and emotion.

2. How do such changes affect the changes in speed and accuracy?

3. How are improvements hit upon? Were they (*a*) accidental, (*b*) partly understood, or (*c*) thoroughly understood beforehand?

Applications.—What applications can you make of the laws you have discovered here to your work?

Write up this experiment and hand it in at the next class-hour.

LESSON 9

RELATIONSHIP OF METHOD, ATTITUDE AND FEELING TO LEARNING (continued)

What Changes Take Place When the Same Performance is Repeated a Number of Times

Method or "Mode of Attack."—There are a number of different methods of doing the mirror-drawing. Most individuals learn through trying this thing and then that. Here and there is an individual who utilizes his knowledge of physics and figures out how his movements should be made. But in even these cases there is considerable of the "try this, try that" performance. Then again, most individuals direct the movement very largely by the eye. But occasionally an individual initiates each new movement in terms of the relationship of his pencil to his little finger. If he desires to move toward his little finger (determined through vision) he then moves his forefinger and thumb toward his little finger—the guidance being in terms of finger-movements, not in terms of vision. The eye is used in this case simply to record the general direction desired and to guide the pencil between the two red lines.

As practice continues the individual may steadily improve on the details of his procedure or he may from time to time try other methods. In the latter case he may return to his first method or he may abandon it entirely. There is no general rule to be laid down as to the course of these changes. Each individual should, however, endeavor to ascertain as accurately as he may just what changes did take place in his own case.

Attitude toward the Work.—Ruger[1] calls attention to three different general attitudes toward one's work. He calls them (1) the self-attentive attitude, (2) the suggestible attitude, and (3) the problem attitude.

The *self-attentive attitude* is illustrated by him by this extract

[1] H. A. Ruger, *The Psychology of Efficiency*, 1910, p. 36ff.

from a man's account of how he solved a puzzle. "It seemed to me that if anybody had given it to me without saying that it was a puzzle (a bona fide one) I would have said it was impossible up to the last minute. I have a feeling now of loss of esteem. I had this all along because I couldn't do something which was made for people with ordinary brains to do. One conclusion that kept running through my mind all the time was that I had a subordinate mind. I couldn't help having a gleeful, self-satisfied feeling when it actually seemed to be coming off, although it was a surprise."

Individuals possessed with this self-attentive attitude expressed themselves as being afraid that the experimenter was getting bored because they were slow, or that he would think them extremely stupid, etc. The principal thing, then, that occupied the minds of people with this attitude was the concern as to their general fitness and as to what others would think of them.

The Suggestible Attitude.—Ruger says, "In two of the men there seemed to be a special sensitiveness toward any movements of the operator which might give an indication as to the course to be pursued. In such cases as this there is a lack of confidence in the self but the attention is directed not to the self but to some other person. The center of gravity, if one may so describe it, of the responsibility is located elsewhere and the suggestions, intentional or unintentional, of the other person or persons concerned are accepted uncritically. This tendency was noted by the writer in his own case in novel situations of a more distinctly social type, such as business transactions of an unaccustomed sort, or other similar cases where persons instead of things were to be dealt with and where the other person was felt to have superior information as to the matter in hand and the self to be deficient."

Probably all have experienced this attitude when attempting to do something new while in the presence of others. This is particularly true when those present are known to know more about the task than oneself. Their presence bothers us; very often we make mistakes that we know we would not make if we had been alone. Here our attention is directed even more toward those who are present than to the work before us. And at such times we are especially susceptible to any indications from these persons as to whether we are doing well or poorly.

The Problem Attitude.—"In contradistinction to these two attitudes, which are certainly not favorable to efficiency," this third attitude is essentially an attitude of self-confidence. "The self-confidence is not one of sluggish complacency, however, but is expressed in a high level of intellectual activity, of attention. Attention would be directed to the thing to be done rather than to appraisal of the self."

In this particular experiment undoubtedly most subjects had somewhat of the self-attentive attitude, or the suggestible attitude, or both to start with. And as practice continued the earlier attitude faded out more and more and the problem attitude took its place. Occasionally a subject displays only the problem attitude throughout the practice period. And occasionally also a subject continues to show the self-attentive attitude throughout, but this is rather rare. Usually there is a noticeable change toward the adoption of the problem attitude.

Some of the factors that bring about this change in attitude are the realization that one is improving, that one can do the task, that another is doing it successfully, etc. But sometimes the latter factor reacts in just the opposite way. Later on in this course, we shall return to this subject of attitude towards one's work, and endeavor to discover the causes of these attitudes and the ways in which the third attitude may be substituted for the first two. In the meantime accumulate what information you can on the subject, as it is undoubtedly one of the biggest problems a real teacher has to face—the problem of making boys and girls and men and women really self-confident about their work.

Feeling.—*Feeling* is technically either *pleasant or unpleasant.* Besides these two aspects of feeling there are the *emotions* of fear, hate, love, anger, etc. It is not likely that a real emotion is aroused in this experiment, except that of anger, and only then in the case of a few individuals.

During the first few trials the work did not go smoothly. One realized that he took altogether too much time in doing the drawing and that there were too many mistakes. Continued failure to accomplish what is desired always is accompanied by an unpleasant feeling. If this is continued too long anger will arise. But as the practice progressed, the work became easier, fewer mistakes were made, and the whole drawing took less time. With each improvement there came less and less of

unpleasantness and more and more of pleasantness. So after a time the original feeling of unpleasantness changed over to pleasantness. Then one was really interested in the task.

As practice is continued, however, the improvement becomes less and less (refer again to Plates I and IV). The novelty of the task disappears, and thoughts come to mind of more interesting or of more valuable performances that one might be doing if it weren't for this required task. The inability to carry out these performances because of the mirror-drawing may then bring again into consciousness unpleasant feelings. Whether one does then change from a pleasant to an unpleasant feeling-attitude toward the task at the close of the experiment will depend on the interplay of the pleasantness associated with the continued improvement versus the unpleasantness due to physical fatigue, inability to do other things, etc.

Even if one does thus swing from unpleasantness to pleasantness, and then back to unpleasantness again, one is very apt to discover that the last two or three trials bring pleasantness again to mind. Especially is this true of the last trial.

(Are these changes in feeling typical of all learning? If so, to what extent should a teacher pay attention to them as shown in his students? How might the second change from pleasantness to unpleasantness be avoided? If these changes are not typical of all learning, how do they differ here from other examples of learning?)

How Do Changes in Method, Attitude or Feeling Affect the Changes in Speed and Accuracy?

It is pretty clear that the changes in speed and accuracy produce very profound changes in method, attitude, and feeling. It is a fair question to ask, on the other hand, if the latter changes affect speed and accuracy. If they do not, it is immaterial whether the learner has a self-attentive attitude or a problem attitude, whether he is in a pleasant or unpleasant mood.

Changes in method profoundly affect speed and accuracy. Even such slight changes as from clutching the pencil as if life depended on it to holding it naturally result in less fatigue and consequently in smoother lines and less unpleasantness. When

careful notes are kept it is often very easy to see that with a change in method there has come decided changes in speed or accuracy. In fact from a study of the time-curve and the accuracy-curve one may often be able to check up the introspections (an introspection is technically an observation of one's own mental processes) of the subject as to just when he commenced to emphasize one of these elements more and the other less.

From our analysis of the three attitudes one may have toward his work, it is clear that one is reacting in the first two cases not only to the details of the mirror-drawing itself but to other details which have nothing to do with the task in hand—details such as one's feelings, one's estimate of himself, the movements of the experimenter, etc. As one can only be affected by a certain number of details, the elimination of these useless details may make it possible for another detail in the mirror-drawing task to affect one. If this new detail is the one that must be reacted to before further progress may be made, then the change in attitude may bring about an improvement not otherwise possible. This is just what we all have noticed many times. Worry, excitement, thoughts of ourselves and others prevent the really important details for the solution of our work from coming into play. The problem attitude represents then that attitude under which we are less affected by unimportant details. The other two attitudes represent conditions of work when certain unimportant details are being reacted to and necessarily other important attitudes are not being reacted to.

How are Improvements Hit upon? Are They (A) Accidental, (B) Partly Understood, or (C) Thoroughly Understood?

Observations from different individuals vary greatly upon this subject. One individual may proceed very slowly and observe very carefully what is to be done and just what he is doing and slowly develop the proper method for doing the experiment. In his case there will be a noticeable number of "planned out" movements. Another individual may make no "planned" movements at all, at least as far as he is able to report the matter. All that such an individual is aware of is that he kept trying first one way, then another, in apparently a very aimless sort of way

and that as time went on he came to realize that he was doing better and better. Moreover, from time to time he also came to realize that he was doing this particular part of the work in this particular sort of a way. For example, that when from the mirror it seemed as though he should move his hand away from his body he then moved his hand toward his body. But the significant part of this discovery lies in the fact that he was already more or less successfully making this movement toward his body when it looked as though he should move the hand away from him before he was conscious of the matter. That is, the improvement was hit upon apparently accidentally and later it became understood. (A few paragraphs below we shall come to see that the improvement was not hit upon accidentally, but was the true resultant of what had gone before, but for the present we may think of it as accidental.)

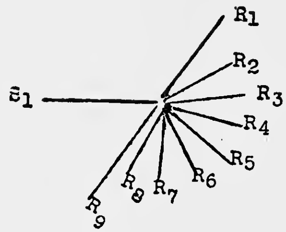
The types of learning illustrated by these two individuals appear at first hand to be very different. The first individual plans out his work, the second hits upon it "accidentally." In one sense they are very different. The former represents the highest type of human learning, whereas the latter represents the lowest type—a type common to both human beings and to animals. But when these two are carefully studied we discover that they only differ in degree, not in kind. Although it is true that the first individual "planned" out some of his methods and movements, yet he did not plan out all of them. Many of them, usually the great majority of them, he first unconsciously learned how to do and then later discovered that he was doing them. We shall want to characterize the learning of these two typical individuals by saying that the second unconsciously learned nearly or entirely all that he did and later became aware of part of what he was doing, whereas the first consciously planned out a few of his movements before starting to do them while learning the rest in the same way that the second individual acquired his.

Learning to do a task similar to mirror-drawing is largely characterized by the unconscious development of movements which, after they have become fairly well established, are likely to become consciously noticed. Such learning has been called *trial and error* learning. The expression is not a good one, but it has been widely used by writers on this subject. The essential

characteristic of this sort of learning is that we do not have at hand a suitable movement (response) to the situation. In terms of situation, bond and response, there is no bond existing between the situation confronting the learner and the correct response. For example, at point 3 on the star-blank one must proceed towards 4 (situation). To do so one must make certain movements (response.) In order to do so the situation and the response must be connected by a bond. Such bonds cannot be formed voluntarily. The only way open is to try one movement after another until the right movement is hit upon. Every time an improper movement is tried it is checked immediately since it leads the pencil in a wrong direction. On the other hand, every time the correct movement is tried it is not checked but allowed to continue. In this way eventually the situation is tied up with the correct response, inasmuch as the bond connecting the two has been used more than any other. The selection of this correct movement is not consciously done. It becomes consciously known only after it is fairly well developed.

This type of learning might be illustrated roughly in this way. Suppose P and Q, who is blindfolded, are standing in the middle of a recently harrowed field, or one covered with snow. P determines just to which part of the field he wants Q to go but he doesn't tell him. Q is to discover this point by keeping walking, agreeing to change his direction whenever P calls out "change" and to keep going when P says nothing. Now when Q starts he is as likely to go one way as another. The consequence is that he will start a number of times and because they are wrong P will so signal and Q will stop and start again. The snow about the starting point will become all trampled because of these starts and stops. But presently Q will hit upon the correct direction, P will no longer signal to stop and Q will continue in the desired direction. If he walks in a straight line he will presently reach the desired point. If he doesn't P will signal to change and Q will then make a few stops and starts, finally hitting on the correct direction again. In this way Q will finally reach the desired point. He has reached it through starting many incorrect movements which were immediately checked and then continuing the correct movement whenever hit upon. Now suppose P and Q start over again. The process will be largely the same as before. But as it will be easier walking

wherever Q has traveled before, Q will be much more likely to continue in old paths than to make new ones. And as the correct direction is the only one that continues for any distance Q will be aided by it much more than by the little short paths that lead in the wrong direction. Still on the second trial Q's guidance will come essentially from P's signals. As P and Q keep up this stunt, the correct path will become better and better formed and Q will gradually come to rely on it more and more and to need



P's signals less and less. After a certain number of trials it is likely that Q could traverse the distance with no mistakes, utilizing the well-worn pathway as a guide instead of the signals of P.

All learning consists in forming a new situation-bond-response combination. In forming such a new combination we must start with some already formed combinations as a starting point. In the case of drawing line 1–2 in the mirror we start with the combination of situation (direction toward one) and response (movement of hand toward body), indicated in the diagram by S1 and R1. But the response R1 is incorrect. Many other movements (R2–R8) are attempted. Each is checked immediately. Finally movement R9 (which is to move hand away from body) is commenced; it is not checked, and so is continued until 2 is reached. The old customary habit, situation (direction toward one) response (movement of hand toward body) has thus been modified so that we now have a new habit, i. e., situation (direction toward one) response (movement of hand away from body). R9 has been substituted for R1 as the response to S1. After a number of stars have been drawn this new habit will then commence to function efficiently. It will do so because the bond connecting S1 and R9 has reached a certain degree of strength.

Why should the nervous current discharge over the pathway to R_1, then to R_2, etc., instead of continuing to discharge over R_1? There are two explanations. First, it seems that after the discharge of current over a pathway there is required a very short interval of time before the nerve cells are in condition to discharge energy again. This factor accordingly tends to divert the current to some other pathway than the one just active. And second, when the discharge does not produce the desired response, when there is a blocking of a discharge in any way, an increased amount of current is released. This phenomenon is called *overflow of energy*. This is easily demonstrated when one tries to solve a puzzle—one becomes more and more excited and exasperated as repeated attempts fail. One sees the same thing illustrated in mowing the lawn. When the lawn mower is jammed, one pushes and pushes, rather than stops and cleans out the stick or clump of grass from between the knife-edges. Only when the pushing fails does one resort to the rationally more sensible procedure. It is very likely that this is largely responsible for the formation of the new bond, for the excess energy discharges over all manner of pathways, including those of very high resistance, and so operates to make them more easily used next time.

The reason we "hit upon" the proper movements "accidentally" and later become conscious of them is apparently that until a bond has reached a certain degree of strength we are not capable of being aware of it. When it finally has reached this degree of strength through use, we then suddenly realize just what we are doing. In terms of the snow field scene Q will not at first notice that he follows his former footsteps in preference to walking through unbroken snow. After a time, however, the difference in ease of walking along a path as compared with walking through the snow is forced upon him. After that he is as much influenced by this detail of the situation as by P's signals. And in the mirror-drawing experiment the subject at first doesn't know how he gets from point 1 to 2. After a time, however, he realizes that to go to 2 from 1 you move in the opposite direction from what you want to, or he may not reach such a generalization but tell you that he disregards what he sees and allows his fingers to guide the movement. In the first case he has clearly in mind what he is doing. In the latter he is more in the stage of Q when he has just commenced to pay attention to the feeling of

path versus no path without thinking particularly about the meaning of this difference.

Let us return now to the original question:—"How are improvements hit upon? Were they (a) accidental, (b) partly understood, or (c) thoroughly understood?" Fundamentally we have in such a type of problem as this mirror-drawing experiment a case where an old situation-bond-response combination is modified so as to give us a new response to the same situation. Whenever the response is changed there results movements more or less of the "trial and error" type, i. e., the starting of many incorrect movements which are immediately checked and the final development of the correct movement through its being allowed to continue. In all such cases the correct movement will be "hit upon" just as "accidentally" as are any of the incorrect movements. Its first use is "accidental." Its second, third, fourth, etc., uses are also accidental. But eventually the bond connecting the situation and the new response reaches a certain degree of strength and the process becomes a conscious one. The normal thing is for improvements to be hit upon first and later to become consciously known.

But there are cases where we do consciously plan out the movement before we commence making any movements at all. These are cases which we shall study more intensively later under the headings of *reasoning* and *transfer of training.* It is sufficient now to say that in these cases the subject has experienced somewhere else in life some situation similar to the one now confronting him and that he now makes use of some of that experience in this case. For example, a subject who has previously studied physics may have learned the principle that vertical lines are inverted as they appear in a mirror but not horizontal lines. This principle may have been connected up as a response to the situation "mirror." Now when confronted with the mirror in this experiment, the mirror detail of the whole situation in the experiment calls to mind the physical law. The law then becomes an added detail to this subject's entire situation. He acts in terms not only of the situation as other subjects perceive it but also in terms of this detail—the physical law. And acting in terms of the law he has little or no trouble with the vertical and horizontal lines in the experiment. This statement must be modified somewhat, however. It is true he will have less trouble

than the average individual if he has in mind the physical law. But he will have still considerable trouble, unless in his physics course or somewhere else he has *actually* drawn objects as seen in a mirror. When one must make a new movement in response to a situation one can only learn to make it by doing it and this doing involves "trial and error." If he has not had this experience, he will profit by knowing the law because he will much more quickly check the wrong movements since he will have a guide in not only what is *seen* but also in what is *felt* in the hands. Knowing that he must move his hands away from him in going from 1 to 2, he will feel in his hands that he is going wrong as soon as he moves in any other way.

REFERENCES

On The Mirror-drawing Experiment

D. Starch, A Demonstration of the Trial and Error Method in Learning. *Psychol. Bull.*, Jan. 1910, p. 20ff.

G. M. Whipple, *Manual of Mental and Physical Tests*, 1915, Vol. II, p. 485ff.

On The Learning Process

Bryan and Harter, Studies in the Physiology and Psychology of the Telegraphic Language. *Psychol. Rev.*, 1897 and 1899, IV. p. 27ff and VI. p. 345ff.

W. F. Book, *The Psychology of Skill*, 1908.

H. A. Ruger, The Psychology of Efficiency, *Archives of Psychology*, No. 15, 1910. Note especially p. 36ff.

Ladd & Woodworth, *Physiological Psychology*, 1911, Part II, Chapter VIII.

E. L. Thorndike, *Educational Psychology*, 1913. Vol. II.

LESSON 10

HOW DOES ONE LEARN A VOCABULARY?

Is the learning of a vocabulary an entirely different performance from the learning of handwriting? Or are there certain parts of each that are more or less similar? What are the processes involved in memorizing a vocabulary? Is there a one "best" method for all individuals or are there different methods which are best adapted to different individuals?

In this experiment E will pronounce a Spanish word and S will be expected to give the English equivalent. If he can't E will prompt him and a little later try him again. As the promptings continue S will gradually learn the vocabulary. Devote your time and ingenuity in this experiment to discovering how S learns the pairs of words. In some cases S will frankly not know, in other cases he will say the sound suggested the English word, in other cases he will have other answers. Endeavor to discover as accurately as possible just how S learned each pair.

A few students, particularly men, take an inordinate amount of time to learn their vocabulary. Yet if there were a thousand dollars at stake they could do the task in a few minutes. Do not allow a wrong attitude to interfere with your work. Get it done quickly.

The Experiment

Problem.—How does one learn a Spanish-English vocabulary?

Apparatus.—E receives from the instructor a list of 25 Spanish-English words, which S is to commit to memory. (If S knows Spanish E should report this fact to the instructor and secure a vocabulary in some other language.)

Procedure.—(1) E prepares a tally sheet similar to the model (Plate VIII) and fills in the list of Spanish and English words to be learned.

2. E supplies S with a list of the Spanish words (but not the English words) which S will keep before him as his prompting list.

3. Trial 1. E will read aloud to S the Spanish words and their English equivalents at the approximate rate of one pair every three seconds. S will follow with his eyes the Spanish words on his list during the reading and will endeavor to memorize the pairs as they are read. He will not write down the English words.

This first trial has, of course, 25 promptings since E read to S each Spanish word and its English equivalent. Accordingly record an "x" in column 1 of the tally sheet opposite each of the 25 pairs of words.

4. Trial 2. S pronounces the first Spanish word on his list and attempts to give its English equivalent. (*a*) If he succeeds, then stop until you have written down S's explanation of how he came to connect the Spanish and English words together. Record these observations in detail because they are the results you are especially interested in obtaining in this experiment. When this is done S pronounces the second Spanish word and attempts to give its English equivalent, etc.

(*b*) If S gives an incorrect English word, write that word in column 2 opposite the appropriate Spanish word. Prompt S as to what the correct English word is. Then have S pronounce the next Spanish word and attempt to give its English equivalent, etc.

List the Spanish words in this column	List the English equivalents in this column	Tally below in the appropriate columns the promptings needed and errors made by S in learning the vocabulary										
		1	2	3	4	5	6	7	8	9	10	11
1.		x										
2.		x										
3.		x										
4.		x										
etc.												
24.		x										
25.		x										
Total number of promptings		25										

Plate VIII.—Showing blank to be used by E for recording promptings and mistakes.

(*c*) If S makes no reply within 5 seconds after pronouncing the Spanish word, mark an "x" in column 2 opposite the appropriate Spanish word and then prompt S as to the correct English word. S pronounces the next Spanish word and so continues.

Repeat the above procedure with each Spanish word in the list. In this way you ascertain whether S has learned the English equivalent for any of the Spanish words after one prompting (your first reading), and if so, how he learned it. And furthermore, you have a record of (*a*) how many English equivalents were given correctly; (*b*) how many were given incorrectly; (*c*) in how many cases no reply was made.

5. Trial 3. Repeat the above procedure for trial 3. Continue with trial after trial until S can give correctly the English equivalent to each of the 25 Spanish words without error and without waiting more than 5 seconds in any case.

6. If you still have time try this additional experiment. After S has recited the Spanish-English pairs correctly, have him start at the bottom of the list and call out the English equivalents as before, reading up the list, instead of down. Continue until S can recite the list correctly. What additional light does this experiment throw on the whole problem of learning a vocabulary?

Results.—(1) Count up the number of promptings (the number of "x's" plus the number of English words which were incorrectly given in each column) and record the totals at the bottom of each column. Plot a prompting-curve.

2. Record all the facts you have marshalled as to how one earns a vocabulary.

Interpretation.—Answer the following questions and give any other conclusions of interest here.

1. How does the learning curve based on promptings compare with the learning curves obtained in learning the alphabet and mirror-drawing?

2. In what different ways did S learn the Spanish-English pairs of words? What seem to be the general laws underlying such learning? Are these laws similar to or different from those related to learning mirror-drawing?

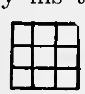
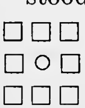
Application.—How might these methods be cultivated? Where else could the same methods be utilized?

Hand in your write-up of this experiment at the next class-hour.

LESSON 11

THE LEARNING PROCESS INVOLVED IN COMMITTING TO MEMORY A VOCABULARY

A foreign word may become associated with an English word in two different ways. It may be learned *through simple repetition*, or it may be learned *through the intermediation of one or more steps*. Take the case of the German word "hund" and its English equivalent "dog." Some individuals will come to know that "hund" means "dog" by simple repetition of the two words together. Other individuals, when confronted with "hund," will think "hound" and then "dog." When the intermediate step is employed the combination "hund-dog" may be learned with one repetition and may then function satisfactorily throughout life. When the purely repetitive method is employed the combination may only be learned after a number of repetitions and even then may not function a few days later.

Consider a second illustration. The Chinese symbol # stands for "a well of water." If one were engaged in committing a Chinese-English vocabulary, particularly at the commencement of the course in Chinese, it is most likely that the combination would be learned according to the first method indicated above—through sheer repetition of the two together. However, if one was instructed by his teacher, that the symbol # was derived originally from  and that the four outside lines had been gradually dropped, and also that the original symbol stood pictorially for a small cluster of houses  about a common well, then it is quite likely that one would need but this simple instruction (this one repetition) in order to retain for life the combination "#—well."*

* The above explanation of the symbol is not technically correct but it is the conception that Annie E. Bradshaw used in learning the symbol. The correct explanation is recorded here as given by C. W. Luh. It is of interest in this connection, as it shows how through associations a term obtains new

Learning through Sheer Repetition—Stimulus Substitution

Consider the fundamental process involved in learning "hund-dog" through sheer repetition or *rote memory.* We start with the abilities:—

1. To pronounce "hund" when we see the printed word "hund,"

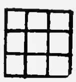
2. To pronounce "dog" when we see the printed word "dog,"

3. To call to mind a considerable number of words after seeing the word "dog," such as, "Toby," "animal," four-legs," "white," "black," "yellow," "cur," etc. All of these latter combinations have been developed through experience and go to make up as a complex whole our complex thought "dog." It is quite likely when we see the word "dog" and say "dog," that there is a more or less simultaneous commencement of the processes to say many or all of the others also.

Such abilities do not impress us as adults. But if we stop to think a moment we realize that small children can not do these seemingly simple things; hence, we must have learned them at some time.

It may be that we have never pronounced "hund" after seeing the word. But we are able to do so because of the existence of still simpler abilities which we possess, namely:—

---

meanings. This word, "well," is derived from an ancient hieroglyph. The square in the middle represents the mouth of the square rail of the well. Around it are walls slanting towards the ground. The resemblance is more remarkable when we write the word in an older style, like  The "well system." During the Dynasty of West Chau (1122–769 B. C.) the land tax was paid in community labor. Each square (about ⅛ sq. mi.) was divided into nine allotments, like  The middle square was public land, the products of which supported the central government. Eight families were assigned to the farmsteads around it, and they worked on it as they did their own farms. The arrangement of the farms, with their fences and pathways looks just like the word (#). So we have come to call it the "well system." "For a time, it was a very effective method, and the management of these farms became a byword for order and cleanliness. So the word became an adjective. In rhetoric we double it (# #) and this means 'very orderly.' "

1. To pronounce "h" when we see the letter "h,"
2. To pronounce "und" when we see the letters "und,"
3. To connect up the two sounds into one word, i. e., "hund."

The more we fall back upon these simpler abilities when attempting to pronounce "hund" the first time the more slowly and with the more hesitancy will we pronounce the word, coupled with an increase in speed and confidence with successive trials. That this point may be better appreciated, watch yourself master the pronunciation of the following words: "handwörterbuch," equilibrating," "concaturating."

Having disposed of the problem of pronouncing "hund" when we see the printed word "hund," let us restate what we have to start with in the form of a diagram.

Situation		Response
(1) seeing "hund"	——→	pronouncing "hund"
(2) seeing "dog"	——→	pronouncing "dog"
(3) seeing "dog"	——→	thinking "Toby"
(4) seeing "dog"	——→	thinking "animal"
	etc.	

The problem is to connect the situation (seeing word "hund") with the existing responses to "seeing dog," i. e., to connect with the first situation in the above table the responses to the second, third, fourth, etc., situations. In terms of a diagram the problem is to develop the dotted line below:—

Situation	Response	Secondary Rseponse
seeing "hund" ——→	pronouncing "hund"	
seeing "dog" ——→	pronouncing "dog" ——→	thinking "Toby"
		→thinking "animal"
		→thinking "cur"
		→ etc.

It is apparent from our experience in the experiment of Lesson 10 that a new connection or bond, such as indicated by the dotted line above, can be developed by mere repetition. Expressed in a more general way we have:—

Situation 1	——→	Response 1
Situation 2	——→	Response 2

with the generalization that *repetition of S1—R1 and S2—R2*

results in the formation of a new bond S1—R2. (Theoretically, two new bonds tend to be formed, i. e., *S1—R2* and *S2—R1*. Practically, one only is formed. Which one of the two is formed depends upon the relative satisfaction to the learner from the two different responses.)

One of the classical experiments illustrating this law was performed by the Russian psychologist, Pawlow. He rigged up an apparatus on a dog to measure the flow of saliva. Then he showed the dog a bone and at the same time gave him an electrical shock. In diagrammatic form:—

1. Electrical shock ⟶ 1. Skin withdrawn from contact.
2. Presence of bone ⟶ 2. Increased flow of saliva.

After a number of such repetitions, the bone was no longer shown and it was found that the saliva flowed in response to the electrical shock just as it had originally done in response to seeing the bone. The experiment thus demonstrated the development of the new bond.[1]

Situation 1, electrical shock ⟶ Response 2, saliva flows.

In this case R2 (flow of saliva) is more satisfying than R1 (withdrawal of skin from contact) and so the connecting S1—R2 was formed.

Now in order to be sure that the reader understands not only the nature of stimulus substitution but also that that is the principle of learning underlying what is popularly meant by rote memory, let us analyze another case. Suppose one wants to memorize "$13^2 = 169$." We have:—

Situation	Response
seeing "13^2"	saying "thirteen squared"
seeing "169"	saying "one hundred sixty-nine"

The two original bonds were developed in connection with learning to read and to solve arithmetical problems. Through repetition the new bond (13^2—169) is formed. The process is stimulus substitution or rote memory.

[1] The term "conditioned reflex" is used in this connection by some writers to cover those cases included here under "stimulus substitution."

Some Corollaries to the Above Law.—(1) If one recites his vocabulary in this way:—

seeing "der"	saying "der"	saying "the"
seeing "hund"	saying "hund"	saying "dog"
seeing "haus"	saying "haus"	saying "house"
	etc.,	

he is strengthening not only the new bond (the dotted line in the diagrams above) but also the bond of pronouncing the word when seen. If he learns his vocabulary by merely looking at the foreign word and pronouncing its English equivalent, thus:—

seeing "der"	saying "the"
seeing "hund"	saying "dog"
seeing "haus"	saying "house"

he is strengthening mainly, if not entirely, the new and desired combination.

But even such a procedure does not lead to the best development of one's vocabulary. It leads simply to the connection of "hund" with "dog." If one, on the other hand, should on seeing "hund" say "dog," then "animal," "cur," "Toby," etc., he would give to the foreign word "hund" the *meaning* that attaches to its English equivalent besides connecting the two together.

Gordon has demonstrated this in an experiment in which one group of students studied an Italian-English vocabulary made up of the words in a stanza of a poem. They were permitted to study the vocabulary in any way they pleased for half an hour. The second group spent this half hour as follows:—(a) the poem as a whole was explained, (b) a close translation was given them, (c) the poem was read in Italian, (d) the poem was read in Italian and translated line by line, (e) the group read aloud the poem in Italian, then each member of the group did so and gave a translation, (f) the passage was read in Italian several times. Both groups were tested at the end of the half hour as to their knowledge of the vocabulary, also again a week later. The errors made by the two groups were:—

Test following study, Group I,— 0.58 errors; Group II,—3.83

Test a week later, Group I,—6.30 errors; Group II,—3.50

"Thus the words learned in lists have the advantage at first but lose it later. In addition to a more permanent learning of the

individual words, the second group were able to recite the poem very creditably.[1]

All those who have studied a foreign language have realized the force of the conclusion in this experiment. Foreign words learned as a part of a vocabulary are not learned in the same way as the same words when learned during reading. The word may be known, for example, in the vocabulary but not understood in the text. There are a number of reasons for this besides the one suggested above, but let us consider it alone here. The foreign word has been connected in the vocabulary lesson with an English equivalent, but it has not necessarily been connected with the great wealth of meaning that the English word carries with it. The foreign word may call to mind the English word but the English word called to mind may not then call to mind its meaning since the foreign word is the situation to which we are primarily reacting, not the English equivalent. Under such a condition of affairs two steps are necessary before we can use the foreign word in the translation, (1) think its English equivalent, (2) think the English word's meanings. If the foreign word had been linked up originally not merely with its English equivalent, but also with that word's meanings this trouble would not have arisen. The difference between learning the meaning of foreign words in vocabularies and in actual reading or conversation comes down very largely to the psychological difference, in the first case of merely connecting the foreign word with an English equivalent, and in the second case, of connecting the foreign word with the English word's equivalent. Meaning can then be thought of as made up of the bonds that are attached to a word. The meaning of "paragraph," or "parallax," or "parallel" for any person is the sum total of ideas (bonds) that these words may arouse.

All of this applies to teaching the use of new words. "Condensation," "evaporation," "expansion," "protective coloring," can be taught so that the only response is a series of words (a definition) or they can be taught so that a whole series of ideas follows requiring the writing of a paragraph to express adequately the idea. Demonstrations, experiments, discussions, etc., help here, as contrasted with the mere use of a textbook.

[1] Kate Gordon, *Educational Psychology*, 1917, p. 173ff.

Learning through an Intermediate Association—Associative Shifting

Having considered at some length the process of learning a German-English pair of words through sheer repetition, let us now consider the process when the two words are learned through the use of an intermediate thought, e. g., "hund-hound-dog." Here again we have the same situation-response combinations to start with as before, i. e.:—

Situation		Response
1 seeing hund	——————→	pronouncing hund
2 seeing dog	——————→	pronouncing dog
3 seeing dog	——————→	thinking Toby
4 seeing dog	——————→	thinking animal
	etc.	

But it is evident, in that the individual went from "hund" to "hound," that there was also the situation "hund"—response "hound." In like manner there was also the situation "hound"—response "dog." There is no difficulty attaching to this second additional situation-response combination. But there is in the first case. Why did "hund" call up "hound"? They have never been together before. Can a situation call up a new response of its own accord with no previous connection between them? Yes and no. Certainly not if there has been *no* previous connection between them. "Hund" would never call up "zojk," or "star" for example. But in this case, although the total situation (seeing "hund") and the total response (saying "hound") have never been together before, there are parts of the situation which have been together with parts of the response. The letters "h-und" in "hund" have been together and in the same order as in "hound." Those individuals who *saw* the connection between "hund" and "hound" did so in terms of these common details in the total situation and the response (hound). But some individuals did not see the connection at first, they discovered it after pronouncing "hund." Pronouncing "hund" became the situation which called to mind the English word "hound." And here again the details—sound of "h" and "nd" in "hund" and in "hound" have been together so that emphasis upon "h-nd" could easily lead to "hound,"

in fact more easily than to "hund," because "hound" is a more familiar word than "hund."

We may then explain the cause of these individuals thinking "hund-hound-dog" by stating that they reacted not only to hund as a whole situation, but to the details of that situation, and that the reaction to the details gave them a response which was already linked up with the final response they desired. This process of reacting to a situation in terms of some of its parts comes under the *Law of Partial Identity.* When we have no bond between the situation and a response (or often a very weak bond) we are quite likely to respond to the situation in terms of certain of its parts to which we already have a strong bond. In this case the bond between "hund" and "dog" did not exist or was very weak from only one or two repetitions. We consequently reacted in terms of the details "h-und" instead of "hund" and thought "hound "—the nearest response to "h-und."

There is still another factor to be considered. The Law of Partial Identity explains why the intermediate word "hound" should come to mind. But in terms of this law one would expect also to be reminded of such words as "hand" or "hind" as well as "hound." A careful analysis of what takes place in learning a vocabulary will reveal that many irrelevant words do flash through the mind. But one "dismisses" them immediately, whereas one "holds on" to relevant words. Moreover, far more relevant words come to mind than irrelevant words. Although the chances should be very decidedly against the relevant word, we shall have to explain this phenomenon on the basis that not only does the word "hund" call up "hound" and other similar words, but the word "dog" also calls up words associated with it directly or through partial identity. As the word "hound" is brought to mind by both "hund" and "dog" and words like "hand" or "hind" or "animal" or "Toby" are brought to mind by only one of the two words, the word "hound" is far more likely to come into consciousness than any of the other words. This is an example of what is known technically as the *summation of stimuli.* A reaction is more likely to be made in response to two stimuli than to only one. One may ignore one ticklish sensation but respond violently to two.

Stimulus Substitution versus Associative Shifting

The essential difference between the person who learned that "hund" means "dog" by sheer repetition and the one who learned that "hund" meant "dog" through the intermediary "hound" lies in the fact that the former developed a new bond, whereas the latter utilized bonds already in existence. The former is the simpler method and undoubtedly the more primitive, the latter is characteristic of some of the learning human beings are capable of as distinguished from what animals can do. The most significant difference is that learning a new bond through stimulus substitution requires several repetitions, or else a very strong stimulus, as the sting of a bee, or fright. On the other hand, through associative shifting, a new combination may be learned sufficiently in one repetition so that it will function efficiently throughout life.

Learning by trial and error and by stimulus substitution are the only ways a *new* bond can be formed. But old bonds can be grouped or linked together in very complex ways. And apparently such *reorganizations* may be easily accomplished. (We shall return to this topic in Lesson 15.)

In early life one has few situation-bond-response combinations. Consequently much of one's learning necessarily consists in forming new combinations. This means a great deal of repetition. Children do not seem to mind it; in fact, they enjoy counting, reciting poems, songs, tables, etc. In later life, having now many bonds, one prefers to learn through recombining old bonds rather than developing new ones. It is often stated that children memorize better than adults. That has been disproved by experimentation. Children *cannot* memorize so well as adults, but they *object less* to doing so. Practically speaking, then, they may be said to memorize more easily than adults.

Use of Mnemonic Devices in Memorizing

Many attempts have been made to develop artificial schemes by which one could substitute associative shifting for rote memory. And one or two such systems are constantly being advertised as panaceas for all our difficulties in memorizing names and faces and dates, etc. Here and there are persons who can utilize such

mnemonic devices but with most persons it is as difficult to manipulate the scheme as to learn the material outright. Here is an illustration taken from one of these systems. To begin with, it should be understood that each number is represented by a letter, as, for example, 0 is represnted by S, 1 by P and 3 by CH, etc. Now supposing one wanted to remember that Spain, Macedonia, Africa, Carthage, and Asia Minor were added to the Roman Empire in 130. Put down the initial letters of the five names, i. e., S M A C A M. This calls to mind "smack 'em," then "smack the lips," then "luscious peaches," and that gives us "Pea CHe S," or 130.

Whether one can remember dates more easily by such devices than by memorizing them outright depends on the individual almost entirely. In some cases one can utilize the steps employed by another, as in the case of learning the Chinese symbol for "well," but ordinarily if one does not originate the steps himself they are of little or no value.

The Effect of Position upon Learning

The first and last two or three pairs of words were learned much more quickly than the pairs in the middle of the list of twenty-five. This is a common occurrence under such conditions. Apparently in learning a vocabulary, for example, such as:—

faire	—	do
chien	—	dog
mouche	—	fly
pied	—	foot

we not only respond with the word "do" to the situation "faire" but also to the situation "first word in the list." Likewise in the case of "chien—dog" we not only pronounce the word "dog" in response to the situation "chien" but to the situation "second word in the list" and very likely also in such a case to the situation "do," since "dog" is so similar to "do." It is apparent that these "position" situations aid us materially in committing a vocabulary to memory but later on when "faire" is met in a French story it may not be reacted to because the element "first word in a vocabulary" is missing. Learning items in terms of

"position" is a risky performance if the items are to be met singly later in life.

The Prompting Method

What we want in life is to be able to give the English equivalent of the foreign word when it is encountered (and vice versa). Through the prompting method we are drilled in reacting to the single words just as we shall wish to do later in life. For that reason it is superior to other methods of learning vocabularies in which we are drilled to react more or less differently from the way we need to respond. The best method of acquiring a vocabulary is through speaking the language and reading it, just as one learns his native tongue. If one must memorize vocabularies the best method is to prepare small slips of paper. On one side write the English term and on the other side the foreign equivalent. In studying the vocabulary pick up the slip of aper, read off the term on one side and recall its equivalent. If this can not be done, turn the paper over and repeat the two terms several times together. After thus going through the list, shuffle the slips of paper and repeat the process. In this way the "prompting method" can be used by one person, and all associations with position are eliminated.

LESSON 12

WHAT ARE THE LAWS OF RETENTION?

We have all had the experience of not being able to remember a fact or do a certain stunt which we have been able to do previously. We say we have forgotten. Let us look into this matter of forgetting and see of what it consists.

In Lesson 4 the alphabet was repeated forwards twenty times and backwards twenty times and in Lesson 10 a vocabulary of 25 Spanish-English words was memorized. These two experiments will now be repeated in order to discover how much has been retained and how much has been forgotten. (Obviously, if S practices before coming to class the experiment will be ruined.) A third experiment is concerned with the extent to which we are able to retain what has been presented to us for a very short interval of time.

(Do not get excited because there are three experiments to do. They will not take very long. If necessary you can easily do the third experiment outside of class upon some friend.)

Experiment I. To What Extent Does One Retain Learning to Say the Alphabet?

Apparatus.—Watch with second-hand.

Procedure.—Have S (the same individual who was S in the Alphabet experiment in Lesson 4) repeat the alphabet (1) forwards and (2) backwards twenty times each. Record the time for each trial.

Results.—Plot on one sheet of co-ordinate paper the curve (1) of learning the alphabet forwards and (2) backwards as obtained in Lesson 4 and (3) the curve of relearning the alphabet forwards and (4) backwards as obtained here. (The results should be worked up after completing the next experiment.)

Experiment II. To What Extent Does One Retain A Vocabulary?

Apparatus.—The same Spanish-English vocabulary used Lesson 10.

Procedure.—Use here the same S as in Lesson 10. E prepares another blank similar to the model in Lesson 10 and writes in the 25 Spanish and English words. He supplies S with a list of the 25 Spanish words. There will be no initial reading of the vocabulary to S as was done in Lesson 10. When E and S are ready S will commence at the top of the list of Spanish words and pronounce the first Spanish word and then attempt to give the English equivalent. (1) If he does so, E says nothing and S passes to the second pair immediately calling out the Spanish word and giving its English equivalent, etc. (2) If S gives an incorrect English word, E will write that word in Column 1 opposite the appropriate Spanish word, and prompt S as to what the correct English word is. S then pronounces the next Spanish word, etc. (3) If S makes no reply within 5 seconds, E marks an "x" in Column 1 opposite the Spanish word, and prompts S as to the correct English word. Then S pronounces the next Spanish word, etc.

Repeat the above procedure trial after trial until S can give correctly the English equivalent to each of the 25 Spanish words without error and without waiting more than 5 seconds in any case.

Results.—Plot (1) the curve of learning the vocabulary as obtained in Lesson 10 and (2) the curve of relearning as obtained here.

Experiment III. How Many Digits Can One Repeat Correctly Immediately after Hearing Them (Memory Span Test)

Apparatus.—List of digits given below.

Procedure.—Using the series of digits given below, read a short series to S at the rate of one digit per second. Take the utmost care to read so as to ensure even tempo, clear articulation, and entire absence of rhythm.

While E is reading the list to S the latter should keep his mouth closed and should not repeat the digits to himself. Directly at the conclusion of the series, let S repeat as much as possible of what has just been read him. (In testing young children E should record in writing S's reproduction; with older individuals it is advisable to have S write down his own reproduction. In this case S should indicate each omission by a dash or a blank space, thus for the series, 9, 4, 7, 3, 5, 8, 6, the reply is 9, 4, 7,—, 8, 5, 6, if S is unable to remember the fourth digit and has interchanged the fifth and sixth digits.)

After having read a short series to S and having obtained his correct reproduction, read him a longer series. If he is again correct, read the next longest, and continue until he makes errors. Suppose his first error is with a series of seven digits. Then secure in all three trials with the series of six digits, three with seven digits, and three with eight digits. In other words discover the longest series that S can reproduce correctly three times, also the shortest series that S cannot reproduce correctly at all in three trials, as well as three trials with any series of intermediate length.

Credit S with his best score, i. e., if he responded correctly to all three of the 5's, to only one of the series of 6's, and no times to the series of 7's; then credit him with a memory span of 6. A correct answer means that the digits are not only all repeated but they are repeated in the original order.

Memory Span Test

2. 7-3	1-6	8-5
3. 2-9-4	8-3-7	9-6-1
4. 5-1-8-3	9-2-7-4	3-8-2-6
5. 4-7-3-9-2	6-4-1-8-3	2-8-3-7-9
6. 8-5-1-7-2-9	2-7-9-3-8-1	9-4-1-7-2-8
7. 2-9-6-4-8-7-5	9-2-8-5-1-6-4	1-3-8-5-9-7-4
8. 4-7-2-9-5-8-1-6	7-1-8-3-6-2-9-5	4-6-1-5-8-2-9-7
9. 7-2-4-9-3-8-6-1-5	4-7-5-2-9-3-6-1-8	2-5-9-3-8-1-4-7-6
10. 8-3-9-5-1-6-2-7-0-4	7-4-0-2-5-1-9-3-8-6	2-6-1-4-0-7-3-8-5-9

In case of any mistake, additional series can be obtained by reading the above lists of digits backwards. In retesting an individual this should be done. Let each partner act as S in this experiment, if there is time.

Results.—Record the memory span of each partner.

Interpretation.—Answer the following questions based on the three experiments.

1. How much do you calculate S forgot during the interval of time between the first and second alphabet experiments? Between the two vocabulary lessons?

2. On the basis of the first two experiments and your general knowledge, do you think that a person who had studied Latin two years would ever forget the first conjugation? Get as good evidence for your view as you can.

3. In what way is the memory span test related to the two experiments on retention? Explain. In what ways do the two differ?

4. According to data furnished by Stiles,[1] children have memory spans, as given below. In the second and four columns are given the average memory spans for boys and girls and in the third and fifth columns are given the memory spans that the poorest child of the best ¾ of each class had. The data are based on records from 751 boys and 834 girls.

	Boys		Girls	
Age	Average	Division between best ¾ and poorest ¼	Average	Division between best ¾ and poorest ¼
6	5.3	5	5.5	5
7	5.6	5	5.6	5
8	6.3	6	6.1	5
9	6.5	6	6.6	6
10	6.8	6	6.4	6
11	6.6	6	6.9	6
12	6.9	6	6.9	6
13	6.9	6	7.2	7
14	7.2	6	7.1	6
15	7.2	7	7.2	7
16	7.4	7	7.2	7
17	7.5	7	7.7	7

[1] C. W. Stiles, Memory Tests of School Children, *U. S. Pub. Health Service*, Reprint No. 316, Dec. 24, 1915.

Gates[1] reports the following distribution for 163 college students in visual and auditory memory span. (His results are converted here into percentages, i. e., 0% of college students have a memory span of 4 with visually presented material, 1% have a span of 5, 9% of 6, 18% of 7, etc.)

No. of digits	4	5	6	7	8	9	10	11	12
Visual presentation........	0	1	9	18	39	21	8	2	2
Auditory presentation	0	7	14	18	35	18	6	1	1

In the light of the figures in these two tables and your own records what do you suppose is the relationship between proficiency in memory span and (1) age, (2) general intelligence?

5. Would you expect as good school work from a child of 12 years of age who has a memory span of 5, as you would from a child with a memory span of 7? Explain.

6. Would knowing the memory span of an individual help you at all in advising him as to the kind of job he should attempt to get? Consider such jobs as these for a girl: saleswoman in a store, cook, telephone operator, stenographer, machine operator, milliner, book-keeper, teacher.

Write up these three experiments following the regular outline and hand in at the next class-hour. Do not forget the heading "Applications."

[1] A. I. Gates. The Mnemonic Span for Visual and Auditory Digits, *Jour. Exper. Psychol.*, Oct., 1916.

LESSON 13

RETENTION (continued)

The subject of retention has to do, of course, with the permanency of our learning. We have seen that in learning we develop a new bond between a situation and its response. We are here interested in discovering whether this bond remains permanently in the same condition as time goes on. When we learned the alphabet backwards we formed new bonds, for example between N and M and between U and T. After an interval of time has elapsed will these bonds function in the same way as they did just after they were formed?

Let us consider the data from a subject who did the alphabet experiment first on June 17 and repeated it again on June 23. His data are as follows:

Trials	Time, June 17	Time, June 23
1	26.0 Sec.	17.2 Sec.
2	22.0 Sec.	16.2 Sec.
3	22.0 Sec.	17.3 Sec.
4	18.8 Sec.	15.4 Sec.
5	17.8 Sec.	11.1 Sec.
6	19.8 Sec.	12.0 Sec.
7	19.0 Sec.	10.0 Sec.
8	18.8 Sec.	10.0 Sec.
9	26.4 Sec.	14.4 Sec.
10	28.4 Sec.	9.0 Sec.
11	16.0 Sec.	15.3 Sec.
12	16.0 Sec.	10.0 Sec.
13	16.4 Sec.	10.0 Sec.
14	12.4 Sec.	9.2 Sec.
15	11.8 Sec.	10.0 Sec.
16	14.4 Sec.	10.0 Sec.
17	9.6 Sec	8.2 Sec.
18	14.4 Sec.	8.2 Sec.
19	11.4 Sec.	8.0 Sec.
20	11.4 Sec.	9.0 Sec.

His last trial on June 17 required 11.4 seconds and the first trial six days later took 17.2 seconds. We can say then that he has

forgotten this performance to the extent of 5.8 seconds (17.2 − 11.4). But this does not mean that he has lost all that was gained from the twenty trials. If all had been lost it would have taken him 26 seconds on the first trial on June 23d, as it took him that long on the first trial of June 17.

As it was, he retained this performance to the extent of 88. seconds (26.0 − 17.2). Clearly, then, *one does lose during an interval of time part of what one was able to do, but one does not lose all.*

Or looking at these data in another way, this individual on his eleventh trial on June 17th beat his first trial on June 23d. We might say then that he lost the effect of 10 trials during the interval of six days, i. e., the effect of the 11th to the 20th trial. But on the other hand the 10th trial on June 23d (9.0 seconds) beat the best record on June 17 (9.6 seconds). That is, apparently only 10 trials were needed the second day to accomplish what was not accomplished in twenty trials on the first day's practice.

To sum up, then, this individual retained during the six days the effect of the first ten out of the twenty trials or an increase in rate of 8.8 seconds (26.0 − 17.2). He lost the effect of the last ten trials or a decrease in rate of 5.8 seconds (17.2 − 11.4).

As for the relationship between what one loses and what one retains, that is found to be dependent on several factors, the chief of which is obviously the amount of practice which entered into the previous learning. Without doubt the more thoroughly one learns a thing originally the better one can remember it. Hence we say that *retention is dependent upon amount of practice* or that *retention is dependent upon strength of the bond.*

The Effect of Time Interval upon Retention

The results outlined above are characteristic of what one retains and what one loses during an interval of time. If the interval is very short, one of course retains proportionately a great deal of what he has learned and one loses very little. If on the other hand, the interval is very long, the relationship is reversed.

Now it is natural to suppose that the longer the interval of time the more one would forget. If one lost 10% during an interval

of an hour, then one would lose 20% during a two-hour interval, or 30% during a three-hour interval. But if this proportion is carried further one would lose 100%, or all, in 10 hours and 110% in 11 hours, which is, of course, impossible. Apparently this is not the correct conception. The rate of forgetting is not proportional to the time that has elapsed. It is actually very rapid during the first few minutes and becomes less and less as time goes on. In Plate IX are given two retention curves, one worked out by Ebbinghaus[1] in 1885, and the other by the writer[2] in 1913.

In Table I are given the data on which these curves are based.

Table I.—Per Cent. Retained After Varying Intervals of Time

Interval of Time	Results of Ebbinghaus, Per Cent.	Results of Strong, Per Cent.
15 Seconds	....	84.6
5 Minutes	....	72.7
15 Minutes	....	62.7
20 Minutes	58.2	....
30 Minutes	....	55.5
1 Hour	44.2	57.3
2 Hours	....	47.2
4 Hours	....	50.6
8 Hours	....	40.6
8.8 Hours	35.8	....
12 Hours	....	41.1
1 Day	33.7	28.8
2 Days	27.8	22.9
4 Days	....	19.3
6 Days	25.4	....
7 Days	....	9.6
31 Days	21.1	....
42 Days	....	6.3

From the figures of Ebbinghaus a person retains approximately two-thirds of what he learned after 20 minutes, one-half after an hour, one-third after 9 hours, and but one-fourth after 2 days. The writer's figures show a somewhat greater amount retained after very short intervals of time and a somewhat smaller amount after long intervals of time. But the principle remains the same

[1] H. Ebbinghaus, *Ueber das Gedächtnis*, Leipzig, 1885.

[2] E. K. Strong, Jr., The Effect of Time-Interval upon Recognition Memory. *Psychol. Rev.*, Sept., 1913.

in both. *We forget very rapidly at first and then more and more slowly.*

Retention of Motor Habits.—The curves of retention given in Plate IX apply to the retention of habits that have been developed with relatively few repetitions. When we turn from such performances to others, such as dancing, skating, typewriting,

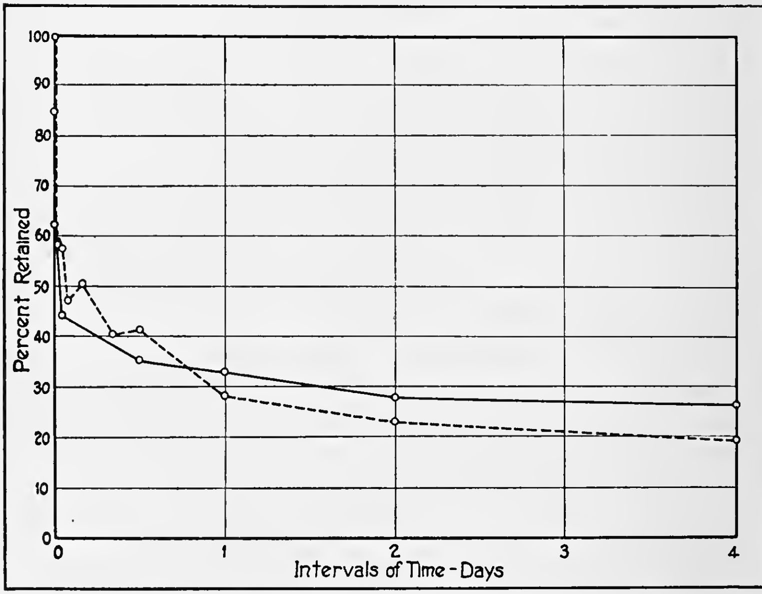


PLATE IX.—Showing effects of various intervals of time upon retention. (Solid line—results on recall memory by Ebbinghaus; dotted line—results on recognition memory by Strong.)

handwriting, etc., we find that there is no such rapid forgetting as these curves of forgetting suggest. After one has once learned to ride a bicycle one will forget relatively little during an interval of years in which the bicycle is not touched. In such a case a person has not only learned to ride a bicycle but he has ridden it time after time until the habit has been, as we technically say, *over-learned* enormously. The extent to which we retain a habit, whether it be of reciting a poem, playing a piece on the piano, or tying our necktie depends then (1) on the interval of time since we last practiced the habit, and (2) on the extent to which we practiced the habit originally. We may draw the moral from

this section that learning any habit to the extent that it will function correctly means that we know it at that time, but only much practice over and above such learning will insure our knowing it months or years later.

Physiological Basis for Retention

The term "bond" has been used in this course to cover the nerve connections involved in learning. Later on certain phases of the nervous system will be discussed. At present only one new conception need be considered. It is that a nervous current encounters resistance in flowing over a nerve; and the more frequently such a current flows over a particular nerve the less the resistance.[1]

A habit or memory is today conceived of as due primarily to the chemical change in the nerve connections whereby the resistance is lowered, thus permitting the nervous current to flow in this particular direction rather than in some other direction.

Consider the analogy in Lesson 9 of Q, blindfolded, learning to go in a certain direction over a snow-covered field, depending first on signals from P and later on the "feel" of the path he has previously formed as distinguished from the untrodden snow. The analogy was presented to show how a smoothly running habit could develop from mere random movements. We can liken the resistance encountered in walking through the snow to the resistance offered to a nerve-current by a little used nerve. And we can liken the decreasing resistance encountered as the path develops in the snow to the decreasing resistance made to a nerve current by a more and more used nerve. At first it makes no difference which way Q travels through the snow, the resistance is equal in all directions. Later Q can travel more easily along the path he has previously formed than in any other direction. Likewise in responding to a new situation (e. g., the attempt to wag the ears) the resistance is great over every possible pathway and there results either no response at all or all sorts of random movements (e. g., frowning, winking, twisting the mouth, raising the scalp, twitching of the toes, etc.). Later the situation produces the one response (moving the ears) and no

[1] See lesson 57, for more detailed discussion, under the heading of Synapse.

other, because the resistance over the nerves connecting situation and response is lower than any other pathway from the situation to any other response. *The new habit is dependent on the relatively low resistance of the nerves which connect situation and response as compared with the resistance of the nerves which connect the situation with any other response.* The same thing is equally true of retention (of memory). In fact, retention is synonymous with lowered resistance over nerves. The resistance is lowered by use and increases again through disuse.

At one time memory was thought of as the storing of nerve cells, similar to storing a storage room with supplies. Such a conception is false. Memories, or habits, are nothing more nor less than expressions of the fact that certain responses will now follow certain situations because of low resistance of the nerves comprising the bond.

With these facts before us we can readily see the futility of supposing that a "memory" can be recalled at any time. A "memory" in this sense doesn't exist. All that actually exists is a system of conduction pathways with low resistance. If the former situation is encountered the proper response will follow because of this low resistance. But the response (memory or habit) will never appear unless the original situation, or a very similar situation (Law of Analogy) is presented.

Relearning

It is clear from what has been established that as soon as practice in learning anything ceases one commences to forget. And, moreover, that one will forget very rapidly at first and then more and more slowly. We should expect accordingly that at the commencement of every writing lesson, every music lesson, every sort of lesson, the beginner will not do so well as he did at the end of the previous lesson. The first few minutes will be spent in *relearning* what has been lost during the interval. It is a common observation that it takes a few minutes in which to warm up to a subject. The athlete finds this to be the case in physical work. One should realize that he cannot do his best work at the start, and not get discouraged but quietly and carefully go over the performance a number of times until he has relearned what

he has temporarily lost. Then he can expect to be doing his best work and to commence trying to beat his previous record—to improve his accuracy and his speed. The writer has found this to be very true in his own case in typewriting. If he endeavors to go at full speed when he begins to write he only makes mistakes and is apt to continue to make more mistakes throughout his entire period of work. But if he will content himself with going slow for a few minutes at the start he can soon go ahead at full speed making but few mistakes.

(Some writers maintain that there are two factors involved here—one due to *relearning* and another to *warming-up*. In studying the rate at which individuals work in all sorts of industries it is clear that they work more slowly early in the morning than later in the day. This phenomenon affords some evidence for a "warming up" factor related to getting started going in the day. And likewise there may be a similar tendency related to starting working at any particular task, besides that involved in "relearning." Very often we do not feel at all in the mood, as we say, and after working for some time become deeply interested and lost in the work. Possibly this change is due to other causes than relearning, i. e., bringing the bonds which are needed for our work up to their highest state of efficiency. The writer, however, believes that the term "relearning" covers most, if not all of these cases, except in the case of the daily warming-up phenomenon.)

Primary and Secondary Retention

A mental process continues to remain in consciousness for a short interval of time. For example I look up a telephone number, lay down the book, put the receiver to my ear, and after hearing from central, say, "Hemlock 2173-L." Central in a moment replies "Line is busy." I hang up and decide to wait a few minutes and then discover the number has slipped from my mind. The retention of the number from the time it was seen in the book until it was recited to Central is an example of *primary* retention. The number was really at no moment out of my mind. But as soon as it had been given to Central, it was dismissed. Now if I could call it to mind again, as I can my

own house number, that would be a case of *secondary* retention or recall. The laws for forgetting so far discussed refer to secondary retention, a term which covers both recall and recognition memory. Primary memory, on the other hand, persists for but a few seconds. That it seemingly lasts longer is due to the fact that we keep repeating the contents over and over and so continue its existence in consciousness.

One of the most interesting facts concerning primary memory is given us in such an experiment as that of Memory Span. Here is measured the number of digits that can be retained in primary memory. An average adult can so hold seven digits. Children differ from adults in this respect. A two to three year old can retain but two digits. A little later the child can repeat three digits. And so as he grows older he acquires a greater and greater ability along this line. Defective children without normal mentality often show marked inferiority in their memory span. A child of twelve years of age with a memory span of four is most likely to be defective. Recently the writer was asked to help a young woman get a job. She was about 18 years old but had a memory span of four. Other tests showed her to be but 9 years old mentally. The failure to reach adult proficiency in memory span would shut her out of such jobs as a telephone operator or stenographer, for in both these occupations there is decided need for primary retention. In fact her low memory span emphasized the uselessness of her attempting to do any work which required attention upon a number of details at the same time. Running a simple machine or selling goods in a five and ten cent store would be as complicated tasks as she could do. And in fact, these were the only jobs this young woman had ever been able to hold more than two weeks.

One of the most useful tests that can be made on children is this one of the memory span. When poor work in school and low memory span are found together, it is quite likely to mean that the child is dull and cannot do good work. When, on the other hand, poor work and a good memory span are found together, it is more than likely that the child is not trying sufficiently, or has become discouraged in his work for some reason or other, or has been sick and absent and missed important points in his lessons. One cannot diagnose all of a child's condition with this test, but it is a good one to start with.

Methods Employed in Studying Retention

It might be worth while to digress a moment and consider the *methods* employed in the two investigations quoted above. Ebbinghaus made up lists of 13 nonsense syllables such as, neb, pid, raz, tud, cor, etc. He memorized seven such lists one after the other to the degree that he could recite the lists once correctly from memory. He then relearned the seven lists after intervals of 20 minutes, 1 hour, 8.8 hours, 1 day, 2 days, 6 days and 31 days. He kept a record of the number of repetitions that were required to learn a list originally and then relearn it. Suppose he required 10 repetitions to learn a list originally and after two days he required 7 repetitions to relearn a list. It is clear that he has saved 3 repetitions (10 − 7) and has lost 7 repetitions after two days as compared with his original learning. Dividing the number of repetitions which he has saved (3) by the number of repetitions which he was originally required to make in learning the list (i. e., 10) we have $3/10$, or 30%, as the amount saved or retained after an interval of two days. (This is a comparable method to the prompting method discussed in Lesson 11, and is technically known as the *learning* and *saving* method.)

In the case of the writer's investigation he employed lists of twenty words. S read the list through just once. Then after one of the thirteen intervals of time employed (e. g., 15 seconds, or 8 hours, or 7 days) S was given a list of 40 words containing the original 20 words and 20 new words all mixed in together. S was required to go through the list and mark the words he recognized as having been in the original list. The percentage recognized gave the amount retained. (This is known as the *recognition method.*)

The two investigations were based on two different types of memory. In the case of Ebbinghaus' work S had to *recall* the list. In the case of the writer's investigation S had merely to *recognize* the words he had previously seen, to distinguish between the new words and the old words. But in both cases the extent to which S could recall or recognize was due to the *strength of the bond* that had been formed during the learning. In the next chapter we shall take up the matter of the strength of the bond and consider it more fully.

Summary

The principal points considered in the lesson are:

1. Retention is dependent on (*a*) the strength of the bond and (*b*) the interval of time which has elapsed since the last practice.

2. We forget very rapidly at first and then more and more slowly.

3. Only through a great amount of practice can one hope to retain a memory or habit over a long interval of time.

4. Relearning at the start of any practice is to be expected.

The following minor points were also touched on.

1. The physiological basis for retention.

2. Primary versus secondary retention.

3. Use of memory span test in diagnosing an individual's capacities.

4. The "learning and saving" method of studying retention.

5. The "recognition memory" method of studying retention.

6. Recall versus recognition memory.

LESSON 14

WHAT FACTORS AFFECT THE STRENGTH OF A BOND?

From our experiments on the learning process we know that practice (repetition) results in our doing the task better and better. This means that the bond or bonds connecting the situation and the response become stronger and stronger. And from our study of retention we have seen that lapse of time in which no practice occurs results in our losing some of our efficiency in the task. This means that such lapse results in a weakening of the bonds connecting the situation and response. Clearly then, use strengthens a bond and disuse weakens it.

Let us turn now and see if there are still other factors which affect the strength of a bond.

The class-hour will be devoted to a demonstration experiment. Each member of the class will consequently act in the role of subject. Carry out the instructions of E as conscientiously as possible but do not worry if you find you are not retaining all that is presented. No one can. Simply endeavor to pay attention throughout the entire experiment and to absorb as much as possible.

The total results as obtained from the class will be given to you before leaving, together with such details of the procedure as are essential for you to know. Write up the experiment in the usual manner, i. e., under the headings: The Problem, Apparatus, Procedure, etc. Work up the data as it seems best to you, bringing out the important facts and principles which are illustrated. Hand in your report at the next class-hour.

NOTE FOR INSTRUCTOR.—Instructions regarding giving this class experiment are given in *Instructor's Manual.*

LESSON 15

FACTORS AFFECTING THE STRENGTH OF A BOND (continued)

Six factors will be considered in this lesson as affecting the strength of a bond. They are—repetition, intensity, interference, reorganization, recency, and effect. Data on the effectiveness of the first four were obtained from the experiment in Lesson 14. The factor of recency or lapse of time since learning was studied in Lessons 12 and 13. The factor of effect of satisfaction and dissatisfaction will be considered for the first time.

Factors That Strengthen a Bond

A new bond is *formed* through trial and error or stimulus substitution. It may be *strengthened* in one of three ways:—

Repetition.—The fact that repetition strengthens a bond has been clearly shown in all of the preceding experiments. In the last experiment when a combination was shown once it was remembered by 5% of the individuals, when shown twice it was remembered by 9%, and when shown three times, by 41% of the individuals. These figures show the value of repetition. It should not be assumed that they represent what would happen under other conditions. The more items shown the weaker is the relative value of repetition. If there were but ten addition combinations to learn a few repetitions would suffice to fixate them. But as there are many more than that very many more repetitions are necessary. The figures in the table, however, do illustrate the value of repetition.

Intensity. (*a*) *Intense Stimulation.*—Of two repetitions the one that is the result of the greater stimulation will result in the greater development of the bond. A tiny burn on the skin will not make us leave the hot radiator alone like a large burn. In physiological terms the release of a large amount of nervous current by stimulation of the sense organs will more materially

affect the nerve connections than will the release of a small amount of current. This is the basis for the factor of intensity as it affects the strength of a bond. In our experiment there was no adequate example of a violent stimulation. If there had been that combination would have been exceedingly well remembered. This might have been accomplished in the experiment by having exposed a combination twice or three times as long, or by having the instructor call out the combination as he showed it. But neither of these is comparable with the intense stimulation we experienced when we caught a bee the first time. Throughout life that one experience of being stung is remembered and we markedly differentiate bees and other insects. The artificial production of great stimulation is difficult to accomplish in influencing others. It is done sometimes through punishment. A better example is where a parent or teacher arranges matters so that the child will get, for example, a slight electrical shock in order to teach him to leave wires alone.

(*b*) *Contrast.*—A stimulus will be reacted to more intensely if its surroundings contrast sharply with it. Thus an ordinary electric light will barely be noticed among fifty others. But if the other forty-nine are made to glow very brightly or very dimly, then it will be singled out. The first and last elements in a series are often noticed more than those in the middle and being noticed more are better remembered. This was the case in learning a vocabulary, but not in the experiment in Lesson 14. The contrast factor of difference in background is sometimes effective, though not always. The intensity gained through contrast alone seldom amounts to more than a few per cent. Men and women do not usually distinguish between contrast and other factors and so attribute to it much more value than is due it. For example, if one is looking for a certain hotel and a light flashes on and off around the hotel name, the name is seen much more quickly and the flashing light is given the credit quite properly. But if one were not looking for the hotel, the hotel name would be ignored almost as much as though the light were not there. The efficiency of the flashing light is due to the contrast effect plus the desire to see the name. And the latter element is the more important of the two. Possibly the true situation is this. If only one or two items are made prominent by contrast then they are noticed to a considerable extent and so

remembered. If many items are made prominent, the intensity factor becomes much less valuable. Contrast the value, for example, of one colored advertisement in The Saturday Evening Post as against twenty or one hundred.

Prominence (intensity or contrast) may aid in learning because the item is singled out and noticed more than the others and, therefore, remembered better.

(*c*) *Emotional Excitement.*—A bond is also strengthened by emotional excitement. If a child is told that punishment will result if he does not do as directed, he is more likely to remember than if the emotional fear were not aroused. Incidents seen in a movie are surprisingly well remembered in contrast to what is learned in school. (This topic is included here, in order to round out this discussion. It will be considered at greater length, beginning with Lesson 31.)

Effect. (*a*) *Satisfaction.*—Thorndike[1] states that when we make a response to a situation and feel satisfied or pleased, then the bond is strengthened because of the satisfyingness. When the response is followed by dissatisfaction, the bond is weakened because of the dissatisfyingness. Moreover, the closer or more intimate the relationship between the performance and the satisfaction or dissatisfaction the more pronounced is the effect upon the strengthening or weakening of the bond.

Effect influences learning because the resulting satisfaction or dissatisfaction establishes, first, a standard in terms of which successful movements are repeated and unsuccessful ones discontinued, and second, the organism continues a process which gives him pleasure and discontinues a process which gives him displeasure. All of Watson's[2] experiments in which he rewards the correct movement and punishes the incorrect ones bear this out. His rats choose the former because they are so constituted that they go toward food and not away from it, avoid an electric shock instead of seeking it. We develop habits which result in our being able to do what we enjoy and we do not form habits which result in unpleasantness.

The Law of Effect which we add to our five other factors means, then, that learning is dependent (1) on the presence of some standard which determines when the learning process (random

[1] E. L. Thorndike, *Educational Psychology*, 1913, Vol. II, p. 4.

[2] J. B. Watson, *Behavior*, 1914, Chapter VII.

movements) is ended, (and it is ended when we obtain a more satisfactory state than before, or are completely exhausted) and (2) on the fact that we will continue pleasant responses but will not continue unpleasant ones.

The second thought in Thorndike's statement is also important. The sooner after the movement has been made that we know we are on the right track or on the wrong track (i. e., experience satisfaction or dissatisfaction), the greater is the value of this factor in learning. If a child has spelled incorrectly or disobeyed his mother then immediate punishment is far more efficient than delayed punishment. In fact, in teaching animals or small children only *immediate* praise or punishment is worthy of consideration. As one grows older one can profit from satisfaction or dissatisfaction after much longer intervals between the execution of the act and the resulting realization that one has performed the act correctly or incorrectly. Nevertheless the shorter the interval of time the greater the value of this factor of "effect." Conscientious high school or college teachers of English labor for hours making detailed corrections in grammar, etc., in themes and then wonder why the same mistakes are made again and again. One reason is undoubtedly that the correction follows so long after the act. Immediate correction would accomplish wonders here as contrasted with this long delayed arousal of dissatisfaction. Grammar school teachers, on the other hand, require each child to write his lesson on the board and call upon him to defend it before the class. Here the interval between execution and realization is reduced to a minimum.

Factors That Weaken a Bond

Lapse of Time.—Experiments in relearning the alphabet and vocabulary have clearly demonstrated that we forget, that our bonds do deteriorate if they are not used. The more recently we have performed an act the better can we do it again. (This factor is often entitled, "Recency" instead of "lapse of time.")

Interference is a factor in affecting the strength of a bond. We have here the formation of two bonds connecting the same situation with two different responses. As both responses can not be made at the same time, when the situation is presented, no response results. If a child in reciting the multiplication table

says 9×7 is 63 and later says 9×7 is 67, when called on by the teacher for the answer to 9×7 he will make no reply in most cases, or wildly guess. To strengthen a bond requires then that no competing bonds be formed at the same time. After a bond has been well developed, however, a new bond may be developed without any great injury to the old one. Herein lies one of the reasons for teaching the addition combinations first and then the multiplication combinations afterwards. If they were taught at the same time there would be great confusion. After the first have been well learned then the latter can be readily learned. But even here it is an advantage to keep them apart in the school work until both are fairly well developed.

"Distraction" is another phase of interference. The playing of a piano in the next room interferes with one's study. Here there is competition between situations, i. e., "music" and "algebra" rather than between the responses to the same situation.

Effect. (*b*) *Dissatisfaction.*—Just as a satisfying effect from the performance strengthens the bond, so a dissatisfying effect weakens the bond. This law explains how new styles of dress and manner are learned with such surprising rapidity and then as quickly dropped. It is a factor that underlies the self-conscious and suggestible attitudes discussed in Lesson 9. When in those attitudes one is responding to any indication of approval or disapproval from within oneself or from another, and one is is reacting to such, even more than to the problem confronting him.

Reorganization

Reorganization is not a factor in the development of a really new bond, of course, but from the practical point of view of learning it is a most important factor since a great deal of our learning consists of linking a situation with a response by means of already established bonds. To link "hund" with "dog" by means of the element "hound" is just as truly learning as to connect them directly together: so also to learn "C is 100" in the experiment of Lesson 14 through linking up "C" with "Roman notation." This type has been called associative shifting, as the learning involves a reorganization or shifting of already formed bonds or associations.

The old, old adage in education of "*going from the known to the unknown*" in teaching emphasizes the value of this type of learning for when we start in to teach a new thing and first consider all of its phases which are already known, the child connects it up with old bonds and so utilizes them in learning.

Novelty.—Human beings are particularly interested in a complex stimulus which stimulates a combination of old bonds that have never before been stimulated together. For example, the writer was lecturing one hot day just after lunch, upon this subject and the students gradually became more and more listless and inattentive. Now either contrast or reorganization could be utilized to get their attention. The writer could have talked louder, or paced up and down the room, or written on the board, etc. All these would be contrast effects and would have some effect. Instead he described in his ordinary tone of voice an advertisement entitled something like this, "How does ——— (an actor) make a cat yawn on the stage every night?" Immediately, the class was awake and paying attention. Why? Because a situation made up of details with very old and well developed bonds was presented. And the combination was new. The words "cat," "yawn," "stage," and "night," have very strong bonds. Such a novel reorganization of old, familiar situations will always attract attention (i. e., be responded to) and will easily be retained.

There is a profound difference between learning *a new thing* and learning *a new combination* of old things. The former is most uninteresting and difficult to "get hold of," despite the popular notion. Consider how uninteresting the first lesson in physics or algebra was, or how little you read of foreign countries you have not visited. On the other hand, consider with what interest the expert milliner reads over technical discussions of the latest styles, or a botanist seizes upon a new flower, or you read descriptions of places you have visited. The average visitor to Niagara Falls or Yosemite is very often disappointed at first. The scene is too new to make an impression. But as he continues to drink in the scene for several days it grows and grows on him because he has commenced to link it up with his other experiences. A big dog is a contrast to an ordinary sized dog. It arouses some notice and is more likely to be remembered than the average dog. But a dog with a pipe in his mouth is a

novelty—a new combination of two old familiar things (dog and pipe). That dog draws a crowd.

In teaching, in advertising,[1] or in any field where one desires to create an impression and have it retained, that impression can be most easily and efficiently accomplished by linking up the parts of the new impression through the use of old bonds, old ways of thinking. A novel presentation (i. e., one capable of reorganization by the learner) accomplishes most. And it is efficient just in the degree that the old is utilized by the learner in connecting the new together. Contrast effects, such as increasing the size of the type in an advertisement or the size of the advertisement itself, or giving it a colored background, or yelling at the class, or writing an assignment in pink chalk, or wearing a florid necktie, do not aid particularly in developing the new bonds presented in advertising, teaching, or salesmanship, and sometimes they positively interfere through distraction.

When the lesson can only be learned through the development of *new* (actually new) bonds, then drill (repetition) is the only solution. This does not mean that the lesson need be recited over and over in the same way. Proper drill is that in which the essential part is repeated again and again until mastered, but in which the repetition is carried on in various ways so that the learner does not tire of monotony, but is stimulated by the changes.

[1] See H. L. Hollingworth, *Advertising and Selling*, 1913, Chapters V and VI for an extended discussion of the factors of contrast and novelty as utilized in advertising.

LESSON 16

HOW TO REMEMBER

We have now some idea of retention, of how habits and memories are retained from the time they were originally developed until needed again. We have seen that these habits fade out as time goes on. We have seen that they are developed and strengthened by such factors as frequency and intensity and are influenced by such factors as interference, reorganization, and effect.

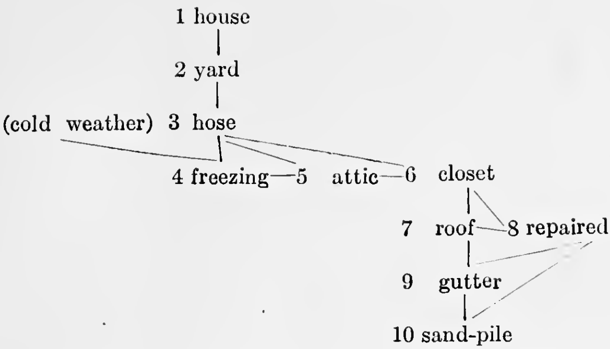
We are now ready to consider the problem of *reproduction, of how we may remember efficiently.*

It is clear that the strength of the bond must be a very important factor in efficient reproduction. If "6 by 7 equals 42" has been said but once, the bond necessarily is very weak and it will not be remembered as it would if the equation had been repeated twenty-five times.

In this lesson we want to emphasize another factor affecting reproduction,—a factor which is just as obvious and just as fundamental as the one concerning the strength of the bond, but a factor which has been grossly overlooked in most psychologies and in the consideration of this problem by educators. Carry through the following experiments and then endeavor to formulate into a law what efficient reproduction presupposes.

General Directions.—Read over and perform each part before going on to the next part.

Part 1.—Have S call out 30 words as fast as E can write them down. Record the time required to call out the 30 words. Then obtain from S a careful analysis of just how each word led to the next word. The analysis can take this form.



The diagram illustrates that "house" called up "yard" and that in turn "hose." "Hose" together with the idea of "cold weather" (an idea not pronounced by S but which came to mind at the time) (record such in parenthesis), called up "freezing" (hose might freeze and be injured). From "freezing" and "hose" came "attic" and "closet" (a good place to put hose). "Closet" started a new train of ideas calling up "roof" (where there had been a leak which was now "repaired." "Roof" and "repaired" called up "gutter" (which needed repairing) and these called up "sand-pile" because the broken gutter caused the rain water to wash the children's sand pile away.

Part 2.—Have S call out 30 words which are unrelated, i. e., have him talk pure nonsense. E should record time again and jot down the words. From S's introspections determine whether S called out all the words that occurred to him. (The time records may help in establishing this point.) Is it possible to think pure nonsense, i. e., to think words utterly unrelated?

Part 3.—Recall (1) the name of your 7th Grade teacher; (2) the names of railroad stations near your home; (3) the authors of text-books used in last year's courses. How did you recall these facts? What ideas intervened between the instructions given here and the proper recall? Note them down. (If S has no difficulty in recalling the items listed in (1) to (3), E should ask for other material which S has some difficulty in recalling. Otherwise the point of this experiment will not be made clear.)

Part 4.—Could you commence playing a piece in the middle where there was no natural break? Can you recite the names of the state capitals without thinking the names of the states? Can you think an idea not led up to by some previous idea?

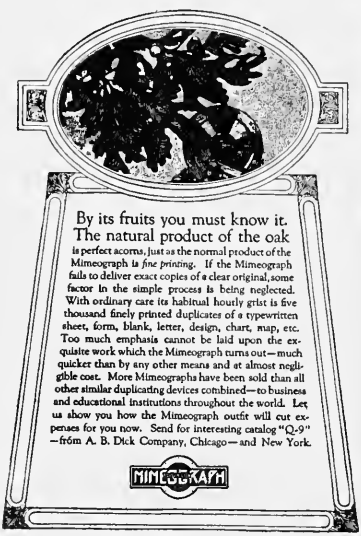


PLATE X.—Which of these advertisements will cause efficient memory of the product?

Part 5.—Answer the following questions with respect to the four advertisements in Plate X: (*a*) What is the principal idea that is being connected up, (associated with) the product? (*b*) Is this idea a situation leading to the product as a response, or is this idea a response to the product? (*c*) Will this association help you to think of the product at a time when you are likely to be buying the product? In other words, when you are in a position to buy this product is the product going to come to mind and if so, is this particular company's product going to come to mind because of the effect of this advertisement? In answering this question, ask yourself the further question: Just when among all the minutes in a day should this company's product flash into mind?

Part 6.—(*a*) What two factors are essential to efficient reproduction? (*b*) How does this conclusion affect the organization of a lesson, or course of study?

Write up the experiments according to the usual form and hand in at the next class-hour.

LESSON 17

HOW TO REMEMBER (continued)

The Two Factors Essential to Efficient Recall

All habits or memories are composed of a situation, a bond, and a response. These are the three components that were present as the habits were developed and they remain linked together. Psychologically speaking, there cannot be a bond which exists alone separated from its situation and response (we often speak of a bond without mentioning its situation or response, but the latter are always implied as being present). When we speak of a habit or a memory we mean nothing more nor less than that there does exist a bond connecting a certain situation with a certain response. If the response occurs when the situation is encountered, we have remembered. If the response does not occur when the situation is encountered, we have forgotten. We have forgotten because the bond is too weak to function.

These axiomatic statements postulate therefore that *the only way a desired response can be obtained is through the presentation of the situation which is connected with that response.* You can only make a child think "64" by presenting some combination of figures as "8 × 8," which are known by the child to equal "64." Everything that we know, every act we are capable of performing, every thought we are capable of thinking, will remain unperformed or unthought until a situation is presented which will call up these acts or thoughts. No one can think nonsense, utterly pure nonsense, where each item is absolutely foreign to every other item. The "flight of ideas" or "incoherent speech" given in Lesson 1 seems to be pretty near nonsense, pure and simple. But careful study shows that the separate items are connected, though not necessarily connected as rational individuals would connect them.

Reproduction is dependent, then, (1) *on the right situation being presented to cause the desired response and* (2) *on the strength of*

the bond between situation and response. The second factor has already been sufficiently considered and needs to be mentioned here only in order to give us a complete grasp of just how reproduction is to be obtained. If the bond is not strong enough, then even if the proper situation is presented, the response will not follow. This means that if I wish to remember the names of persons to whom I am introduced I must first of all definitely connect up their appearance with their name and, second must practice this connection a number of times. With practice one can learn to note peculiarities in many an introduced person that through the "law of analogy" will readily call up the individual's name. Only a few repetitions are necessary to develop such connections between appearance of the individual and his name. In the cases where no connection between appearance and name appears the bond must be developed through repetition. Having formed a sufficiently strong bond, then, between the appearance of the individual and his name whenever the former is encountered the latter comes to mind.

Until the bond reaches a certain strength it will not function so that the response will occur when the situation is presented. Starting from zero strength of a bond we may have to go to "n" strength before we reach the necessary strength. The term *threshold of recall* has been used to express this idea. Until the bond reaches a certain strength, i. e., rises above the threshold, the response will not be made. This conception of a threshold explains the oft heard expression, "I know, but I can't tell." The individual recognizes the situation, actually knows that he has responded to the situation before, but because the bond connecting the situation and the response is below the threshold, he cannot respond. The expression, when honestly employed, means in the school room that the child has not gone over his lesson sufficiently—that the situation-bond-response elements have been practised but not often, or intensely, enough to insure recall.

Recall and Recognition

Certain distinctions between recall and recognition have been pointed out already in Lesson 2 in discussing the steps of a sight-spelling lesson. Still other distinctions may be considered now.

The writer[1] suggests that recognition is to be explained as follows. On meeting a stranger I react in a certain definite way. The reaction is a very complex affair composed of certain thoughts concerning him, a certain facial expression, etc. Since this total complex reaction has never occurred before it takes longer to respond than it will the second time. (Successive repetitions lower the reaction time and increase the "ease" with which the reaction is made.) Now when I meet this stranger again this total complex reaction is more or less exactly repeated. This time the reaction is made more quickly and with more ease. I am so constituted that I can "note" that the reaction has occurred more easily than if I were reacting to a stranger for the first time. The "noting" is recognition. I don't actually "note" these facts, instead, I simply realize I have met this individual before. Recognition appears, accordingly, when the same response is made, that was made before and the reaction occurs "easier" than if it were an entirely new response. According to this view, "strangeness," "recognition," and "familiarity," constitute mental states which are determined by the "ease" of the reaction.

Upon encountering a situation to which one has previously reacted, he may (1) both recall and recognize, or (2) recall but not recognize, or (3) recognize but not recall, or (4) neither recall nor recognize. When both recall and recognition are present there is complete *reproduction* (memory in the usual sense). The response is again made and we realize we have made it before. "Lucky guesses" in examinations are examples of recall without recognition. The answer is correct but it is not so recognized. Unfortunately, all such guesses are not correct. But the percentage is large enough to warrant such guessing unless it is important that no mistake be made. The third case of recognition without recall is very familiar. We have all had to say apologetically many times, "Yes, I recognize you perfectly, but I can't seem to remember your name." Probably here we make the same general response in terms of facial expression, liking or disliking, noting color of hair, eyes, etc., that we did before and recognize on this basis; but fail to recall the name because the bond between his appearance and name is too weak

[1] M. H. Strong and E. K. Strong, Jr., The Nature of Recognition Memory. *Amer. Jour. of Psychol.*, July, 1916.

to function. In the case when recall and recognition both fail to occur, the bond is too weak for recall or recognition, or a different set of reponses are made. Several men I first met in uniform, I have failed to recognize, probably for this reason.

"Training" the Memory

Much of the work now required of children in school is justified by educators on the basis that it trains their memory. The fallacy in this assumption should be immediately clear to every reader. Substituting the word "habit" for "memory," we would read, Mary learns memory-gems in order to train her habit. Such a statement means nothing, nor does it mean any more when stated, Mary learns memory-gems to train her memory. Memory and Habit are only abstractions. Memories and habits are concrete and numerous. Training Mary to make one response to a certain situation does not aid her directly in making another response to a new situation. Memorization of a poem is one thing, of a Latin conjugation another. And neither helps one to learn chemical formulae nor the various kinds of dress-goods. Each specific habit must be developed by itself. Of course, it is not meant that learning Latin words does not help in learning botanical terms to the extent that there are common elements in the two. But that phase of learning will be discussed in Lesson 49.

Is there any justification, then, for the notion that one gains something from memorizing poetry which will help him in later life?

To make the matter absolutely clear let us at the start again affirm that memorizing one passage does not directly aid in memorizing even another passage. James found that training in memorizing one poem, such as the first book of Milton's *Paradise Lost,* did not improve the ability to memorize other poetry at all.

What then is accomplished by such training? Primarily, various habits of attitude towards one's work are developed, also various ideals concerning work, and various methods of memorizing. In training a child to memorize we are at the same time training him to neglect other things about him and to react to the one thing before him—the passage to be memorized. We

give him a new attitude toward the whole thing—before he may not have realized there was such a thing as a memorized passage. Now he knows there is, and that he can so learn himself. He has likewise learned various methods or devices which are useful in memorizing—e. g., that one must pay attention to the detailed parts of the passage as well as to the general whole of the thing, that one must make an effort to learn—listless repetitions are of little avail, etc. In a general way, then, a student does not improve his sheer capacity to memorize by memorizing but he does improve in a practical way in that he knows how to go to work, that he can learn, etc.

Is not the psychologist making a distinction here which is of no value to the teacher, when he says memorizing does not improve one's capacity to memorize, but nevertheless that through the development of habits and ideals and methods it does make future memorizing easier? Not at all. The distinction is very vital. Instead now of the teacher concentrating her efforts on getting a great deal of memorizing done in order to make her pupils more efficient, she must direct her efforts toward seeing that her pupils do develop proper attitudes toward the work, do memorize correctly. Such a change upon the part of the teacher might result in her cutting down very materially the amount to be learned but in training the children so that they would learn what they did memorize in a far more efficient manner.

How to Memorize

The following eight principles must be borne in mind in memorizing:—

1. Repetition is essential. The longer the period in which the material is to be retained the more the repetitions that are necessary.

2. The first few repetitions will produce noticeable returns; the later repetitions will produce scarcely noticeable returns. These later repetitions are just as important in effectuating a mastery of the material. (Recall data on learning curves.)

3. Reviews at longer and longer intervals are necessary in order to insure that the material will be permanently retained.

4. As soon as possible, cease simply reading through the

material and commence attempting to recall it, prompting oneself when one can no longer recall.

5. Learn by the *whole method* rather than by the *sectional method*. In other words read through and through all the material, rather than memorize one small part at a time. The best method in detail is (*a*) read through the entire passage a number of times to get an idea of it as a whole; (*b*) read through very slowly making sure what each phrase and clause means, so obtaining a detailed grasp of the meaning of the whole selection; (*c*) attempt to recall, prompting oneself just enough to go on. When this stage has been carried to the point that some parts are easily recalled, and other parts are not, then (*d*) take up the difficult parts one at a time and master them. (*e*) Return to the recall and prompting method, going through the entire passage again and again until memorization is complete.

6. *Distributed* learning is superior to *concentrated*. That is, don't attempt to memorize at one sitting, but follow the procedure in (5), doing a little today, a little tomorrow, and so on, until the material is mastered. It is surprising how easily most individuals memorize when they only go over the material once a day.

7. It is not sufficient that one make some reaction to the material to be mastered; one must react to the material with the specific response of recalling just that which is to be retained. An example will make this clearer. Myers[1] gave classes of individuals the impression that they were being tested in speed and accuracy of spelling. He called out six words, one after the other, and after they had been written down, instructed the persons to turn over their paper. They were then called upon to reproduce the list of six words in their proper order. Ordinarily adults would have little trouble in writing out six words just previously heard or written down. But only 5% of 236 college students and school teachers succeeded in making a perfect score when their attention was directed to spelling and not to remembering the six words and in the correct order. Leaving aside the matter of order of the six words, the number of words recalled was as follows:—

[1] G. C. Myers, *A Study in Incidental Memory*, 1913.

6 words were recalled by 25%
5 words were recalled by 41%
4 words were recalled by 28%
3 words were recalled by 5%
2 words were recalled by 1%

The term *incidental memory* has been applied to those cases where we have reacted to a situation in some way or other and then are called upon to make the specific reaction of recalling the situation itself. Another interesting example of this same thing consisted in asking individuals to draw a representation of a watch face, with Roman numbers. Of 200 persons so tested all but 21 put in "IV" instead of the "IIII," and all but 8 put in a "VI." Looking at a watch face thousands of times to tell the time does not equip a person with the ability to recall the details of that watch face.

Because one has made one reaction to a situation does not imply that he will be able to make the specific reaction of recalling the situation itself. To memorize, one must react to the material with the specific reaction of recalling the material; no other reaction is of very much avail.

8. A real aim or motive must be present, else memorization will not occur. That is, without "determination to learn" little will be retained even when the individual complies with (7). For example, one individual has looked up the squares of 13 to 25 hundreds of times and still does not know them. A few repetitions made with the determination to learn them would have been sufficient to insure the proper responses when needed.

Hollingworth[1] reports that a number of individuals were required to call off as fast as they could the names of five colors arranged in an irregular order, twenty times each. This they did 220 times. No one was able to do more than give a few groups of three or four colors in their proper order, and even the proper location of these groups in the series or on the card was impossible. The assistant who had gone over the test about 3,300 times knew scarcely more about the order of the colors than did the subjects themselves.

To secure effective determination to learn requires the presence of some aim or motive. This is, after all, the most important

[1] H. L. Hollingworth, *The Influence of Caffeine on Mental and Motor Efficiency*, 1912, p. 17.

key to memorization. Without a motive the desired results will not occur, not because of an inability, but because of lack of desire.

The writer recalls how stubbornly he refused to memorize "The Lotus Eaters" for an English teacher he disliked on the ground that he couldn't, whereas, at about the same time he memorized "The Shorter Catechism," questions and answers, from cover to cover, in order to earn five dollars. Teachers must present motives for such work. They should go farther than this and so develop boys and girls that they will want to memorize other beautiful passages (or other material), or, at least, read and enjoy such things for their own sakes. (This topic will be discussed in greater detail in Lessons 32 to 43.)

9. One must have the "problem attitude" toward his work (see Lesson 9). One must believe that he can learn. Gilchrist[1] divided a class into two sections of equal ability after the class had gone through a certain assignment. He then addressed the first section as follows: "A hasty examination of the papers of the test just given shows that the members of this group *did not do so well in the test as the average twelve year old child.* I ask you to take the test again." The following "remarks" were addressed to the second section: "A hasty examination of the papers of the test just given shows that the members of this group *did exceptionally well.* I ask you to take the test again." The test was then repeated with the two sections.

The first section actually lost 5% (the scores being 71.75 and 68.38), whereas the second section gained 79% (the scores being 72.42 and 129.50). If a difference of 84% in work done can be secured from college students according as they are told they have done poorly or well, such differences in attitude must be constantly borne in mind by educators. It would be far better to spend the class hour in securing a favorable attitude than to devote it to drill when a class is "out of sorts."

How to Secure Efficient Reproduction

A far more important problem than "how to memorize" is that of "how to secure reproduction" of that which has been

[1] E. P. Gilchrist, Satisfier versus Annoyer. *School and Society,* Dec. 2, 1916, p. 872. (A mistake in the published table accounts for the difference in results given there and here.)

learned. For if an individual cannot utilize what he has learned, it is of little value to him.

We teachers teach facts all right, we form bonds connecting one fact with another in abundance, but we do not so teach that when a need arises in life for these facts there will be recalled to mind what was taught years before. All of us have lamented when it was too late. "If I had only thought of that, and I knew it perfectly well." Knowledge that is not used when needed is mighty near worthless.

We have seen that reproduction will occur when (1) the bond is of sufficient strength to function and (2) the situation to which the response is linked is presented. The "strength of bond" factor must not be overlooked. We shall, however, reserve to Lesson 47 further discussion of this point. What can be done by teachers to provide for efficient reproduction in terms of the second factor?

Examples of Efficient and Non-efficient Reproduction.—To make the second factor clearer, let us consider some cases where individuals did recall and also did not recall, due to the presence, or absence, of the necessary situation.

1. Multiplication combinations are taught correctly in school to secure efficient reproduction. "4 × 9" is presented and the child is called on for the response. The response "36" is needed when "4 × 9" occurs in life. When the bond connecting "4 × 9" and "36" has been sufficiently repeated, the product will be forthcoming whenever the situation is presented.

2. A number of years ago a railroad engineer was examined in court concerning a terrible accident. The accuracy of his testimony depended on whether it was possible for him to have done as many things as he said he did in the exceedingly short time which it was proved had elapsed between his passing a signal and crashing into the other train. In his testimony he stated that for years he had planned what he would do in case of an accident. And at least once a day he had gone through the motions of stopping his train and doing those things needful in an emergency. During those years of railroading he had developed the necessary habits until when the emergency came he did what there was for him to do in an exceedingly short time. This is the way to train oneself to meet emergencies.

The only way to secure efficient reproduction (proper action)

is to do those acts themselves as responses to the situations which may arise. From principal to kindergartener the only way to prepare to react to a sudden fire is by going through the fire drill until it has become second nature. It does little good to read about how to save a person from drowning. The situation which will confront one will be an apparently lifeless body, not a book, and the responses that are needful are certain movements of the hands and body, not a lecture on the subject. To be prepared is to have gone through the performance using a friend in the place of the lifeless body.

3. The writer was told one day by a friend who was interested in High School physics that he did not believe 10% of a certain group of college students could repair their own door bell when it was out of order. Yet all of them had had a course in physics in High School including the subject of electric batteries and door bells. Very likely many of them could respond to the situation "Examination question, 'Draw a diagram showing how you would connect up an electric bell'" by drawing the desired diagram. But apparently this situation is so different from the actual situation of finding a door bell in the kitchen, the batteries in the cellar, and the push-button beside the front door, that knowing the response to the first does not help in responding to the second. Of course, the responses are very different. One involves using a pencil and paper, the other a step-ladder, screw driver and knife. Training the hand to draw is not training the hand to turn a screw driver, etc. Undoubtedly, before we shall make our physics course as practical as it should be, we shall have to introduce real situations into its teaching. If an electric bell circuit was set up in the laboratory and then put out of order and the students were called on to fix it as one of the regular assignments there would not be a great number of physics graduates who could not apply their science to this life problem.

4. Consider two advertisements that might have been included in Plate X. One depicts a man seated at a dining room table eating breakfast all alone, with a bottle of milk and a package of Kellogg's Corn Flakes prominently displayed. The heading beneath is "My wife's gone to the country." The other advertisement reproduces the statue of Venus de Milo, which occupies most of the page. The words "Kellogg's Corn Flakes" are also conspicuously present. This second advertisement will not

secure effective memory because it associates corn flakes with Venus de Milo. Such a thought does not make one want to eat corn flakes and when, on the other hand, one thinks of this famous statue, one is not in the mood or place to buy breakfast food. But the first advertisement is planned so as to develop effective memory. A husband, eating a solitary breakfast, is likely to have this scene flash into mind suggesting to him the desirability of this sort of breakfast which he can so easily get for himself. Or the wife, planning for her husband's breakfasts in her absence may have this scene come to mind and so think of corn flakes. In the case of either husband or wife a situation is presented to them which they are likely to encounter in life and the situation thus calls to mind the product.

5. Let us consider a far more general type of behavior, where it is clearly impossible to connect all the situations a boy or girl will meet in life with the proper responses. In such cases a *general conception* has to be developed. A respect for property rights can be grounded on the conception that practically everything belongs to someone. This is established by leading the child to see the truth of it in many particular cases. The conception can further be strengthened by giving him things of his own and respecting his ownership of them. Such a child on encountering the situation, "Money on counter. No one present," will not react to just those two details, but to these plus the third one of, "All objects belong to some one." The richer this detail is in meaning, *i.e.*, the more strongly it is bound to the idea of leaving things alone, the more likely it is that the response to the money will be a reaction to the third detail and not to the first two. The third detail is of course supplied by the boy himself but it is called up by the first two due to careful training. The more abstract the training concerning honesty, the less likely is it that the details. "Money on counter. No one present," will call it to mind. The more concrete the training, the more it has had to do with actual examples, the more likely that the concrete money will recall the training. Most abstractions are far removed from the little affairs of life. Honorable conduct must be developed through supplying the individual with proper responses to the situations which will actually confront him.

Efficient Development of General Habits, or General Conceptions.—The habit of saying "36" upon seeing "4×9" is

specific; the behavior of leaving other people's things alone is general. When "courtesy," or "tact," or "courage" are used, we have in mind many habits, some of which are specific, like taking off one's hat to the ladies, but most are general, like saying inconsequential things that make people feel at home. Much of what is meant by "culture" is covered by general habits. These need to be developed in school as much as more specific ones.

Far more stress must be placed upon the determination of what general conceptions are to be taught than has been done. Take the case of History of Education. Is this course required of prospective teachers in order to acquaint them with the history

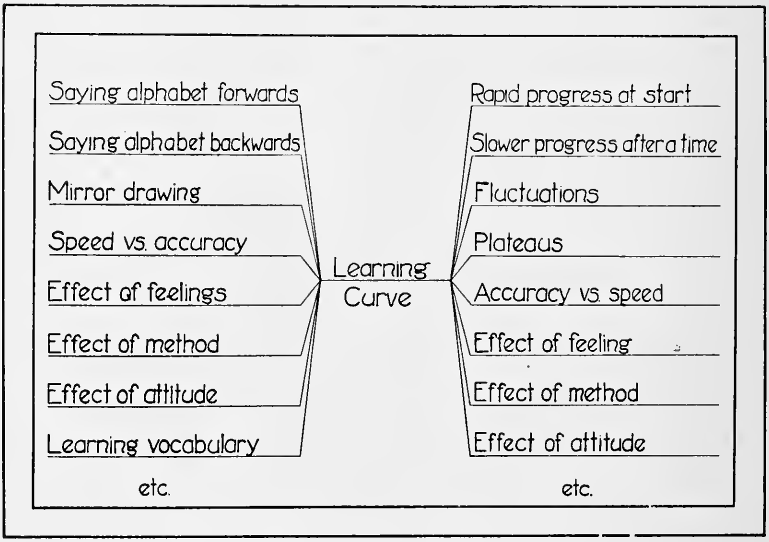


PLATE XI.—Illustrating the functioning of a "central conception."

of educational movements or is it required in order to fit them to teach more efficiently? The usual text-book answers that the former is the aim of the course. Consequently the details of the course are built around such topics as, Greek Education, The Renaissance, Realistic Education, and the like. How many graduates of such courses ever use what they learned? But if the other aim was before the text-book writer, specific problems of modern education would appear as chapter headings followed by a presentation of the experiences of the past bearing on the

problem. The graduate of such a course could hardly help using the material in such a course because every time one of the problems discussed in the text was encountered, what had been studied would flash into mind. As it is, one does not meet "Renaissance" or "Realistic Education" in his daily work and so does not have the ideas linked to them come into mind.

Consider in this connection the organization of this text-book. Over and over again you have performed experiments and plotted learning curves. From these curves you have learned many facts about the learning process, e. g., rapid progress at the start, slower progress after a time, fluctuations, that the shape of the curve tells interesting facts about the learner's previous training and about his natural ability, relation of progress to changes in method, to feeling, etc., etc. You can never again see a learning curve and not think many of these facts for they are connected with the curve. Moreover, when you see a particular curve you will think of those principles and facts which that curve suggests. In other words you have learned to understand a curve. In terms of the diagram (Plate XI) bonds have been formed between "learning curve," the *central conception*, and all the items to the right.

But all of this is not enough, although it is just where most instruction stops. It is necessary that you be so taught that it will not be left to accident that this central conception (learning curve) will occur to you. For it is the key which will unlock all your knowledge on this subject. If it is not present you will probably not recall the remainder of the material. How can it be arranged that you will think "learning curve" when confronted by certain problems in teaching? It can be accomplished by associating many such problems with "learning curve." You have already made such associations in the lesson on vocabulary study and on teaching the violin.

In terms of the diagram (Plate XI) bonds have been formed between a variety of teaching situations and the central conception, "learning curve."

The writer has so organized the material in this course (1) that many concrete cases in school room procedure have been associated with the learning curve and (2) that the learning curve has been associated with a great deal of the material in the course. It is impossible to connect up each detail in life with the proper

details in this course. But you can be trained to think "learning curve" when confronted with a school problem and then go from the intermediate step (learning curve) to almost anything in this course. When Mary Ann does poor work you will now respond to "Mary Ann and her poor work" plus "learning curve," and then you will recall "plateaus," "attitudes," "changes in method," etc. Your analysis of her trouble in terms of all these detailed considerations will enable you to decide very much more wisely just what to do with her.

Put things together in school that need to go together in daily life and put them together in the same way that they will occur in life. If the material is complex, as in this course, then select *one or more central conceptions and connect up situations the child will meet in life with this central conception* and *also connect up the central conception with the facts and principles in the course.* In this way will you provide for efficient reproduction.

LESSON 18

SUMMARY OF LESSONS 1 TO 17

Components of Behavior

Behavior can be broken up into the three components of *Situation, Bond,* and *Response.*

Some Bonds are Unlearned, Others are Learned

All acts of behavior involve a response to a situation. And this condition postulates the existence of a bond between situation and response. It is evident from the experiments which have been performed that bonds are formed—that at one time in a person's life certain bonds did not exist which later came into existence. Such changes are what is meant by learning—the development of new bonds. A still closer study of man's behavior, especially when he is an infant, leads us to realize that there are some bonds which do not develop through the process of learning. Such bonds develop naturally: just as naturally as do man's teeth, hair, blood vessels, or digestive system. Situation-bond-response combinations which develop naturally are referred to as *reflexes* or *instincts.* Combinations, on the other hand, which are acquired through learning are termed *habits.* (To be discussed further in Lessons 31 to 37.)

Reflexes and Instincts.—A reflex is an act in which there is a simple stimulus as the cause of the excitation followed by a simple response, the bond or connection between sense-organ and muscle being unlearned. Reflex acts are such as jerking the hand away from a hot stove, winking when an object suddenly comes toward us, coughing when the throat is irritated, etc. An instinctive act, on the other hand, is one in which there is a more complex situation, ordinarily, followed by a more complex response, the bond being also unlearned. Instincts would be illustrated by such behavior as a mother's reaction to her baby's cry, fear and flight from a large animal, a boy's interest in girls, etc.

The most important point to note in all these cases is that the response is always one that is made naturally without any training. In other words, the *bond* connecting situation and response is *unlearned.* This means that nervous connections are already formed between sense-organs and muscles, so that when man is confronted with certain situations he responds automatically, immediately and without conscious guidance.

There can be no sharp line of demarcation drawn between reflexes and instincts any more than there can be a sharp division of all men into the two groups of short and tall men. Some men are undoubtedly short or tall, just as some unlearned performances are clearly reflexes or instincts. But most men are neither decidedly short nor tall. In the same way most unlearned performances can be classified either as reflexes or instincts depending upon the definitions set up. In a general way, reflexes are simple acts, involving little or no consciousness of what is being done and seemingly carried on by only a part of oneself, as the hand, eye, etc. Instincts are more complex, consciousness is involved, and I feel that I myself am involved, as when I pet a baby, or run from a bull, or get interested in a girl.

Habits.—On the other hand, habits are situation-bond-response combinations which have been developed through training. At one time there was no bond. Unless such new bonds were formed man would not advance beyond the limits of his reflexive and instinctive equipment.

Learning and Forgetting

Learning consists in the formation of bonds between situations and responses and the strengthening of the bonds so that they function more efficiently. *Forgetting* is the opposite of learning; it is the effect of bonds becoming weaker and weaker until they no longer function. A somewhat similar effect is produced through *interference.* Freud claims that forgetting is also due to the fact that we want to forget, because the memory is unpleasant. It is for this cause, he says, that we forget a troublesome engagement. This type of forgetting may possibly be explained as due to interference. Take the case of the boy who is told that when he comes home he is to chop wood. There is here

interference between spending the afternoon chopping wood and playing football. The latter is the stronger response due to habit and interest, and so "interferes" with the other response. Most failures to chop wood are sheer disobedience, but sometimes Freud is correct in saying that the duty is actually forgotten.

The Laws of Learning

The laws of learning are the laws as to the formation; strengthening, and reorganizing, of bonds. For example: There is rapid movement at first with less and less improvement as practice continues; improvement is never continuous—there are always fluctuations in the curve of learning; under certain conditions plateaus develop—periods of no apparent improvement; and there is a limit to improvement (physiological limit) beyond which we cannot go, but which is practically never reached, due to lack of sufficiently strenuous practice.

Learning may be considered in terms of: (1) The formation of new bonds, (2) the reorganization of situation-bond-response combinations, and (3) the strengthening of bonds.

Formation of New Bonds

A new bond is formed through trial and error or stimulus substitution.

Trial and error learning occurs when the response that is desired (1) is not connected to any stimulus at all, (2) is not connected to any element in the situation, or at least to any potent element in the situation and (3) is a complex response and the proper sequence or coordination of movements is not known.

There are very few examples of the first case where there is no stimulus connected with the desired response. Learning to wag one's ears is, however, one example. Here there actually exist motor nerves running to the muscles that move the ears but there is no stimulus that will set off the movement. As the movement has never been made, one does not know what it is. And it is difficult to ascertain from watching our own performance in a mirror when we have really made the movement we have seen another make. For sometimes we move our ears but also our whole scalp, or the side of our face. The latter element we do

not want. To acquire this stunt means that we must just keep trying and trying. Because of the phenomenon of overflow of energy (Lesson 9), eventually this little-used pathway to the ear muscles becomes well used and under conscious control.

The tri-trix puzzle, (see Plate XII), illustrates the second case, where the desired response is not set off by the situation. One accordingly makes all manner of random movements in the endeavor to get the four shots into the four outer holes, and usually does not succeed. But if one gets in some way or other the idea of whirling the puzzle, it is solved. The random movements occur because no element in the situation sets off this necessary response of spinning. One of the important functions of teaching is to eliminate useless trial-and-error learning by so manipulating the situation as to have before the learner those elements which lead him to act as desired. The student of this text, for example, has learned a great deal from the experiments that he has had to perform and he has learned it with a minimum of trial and error.

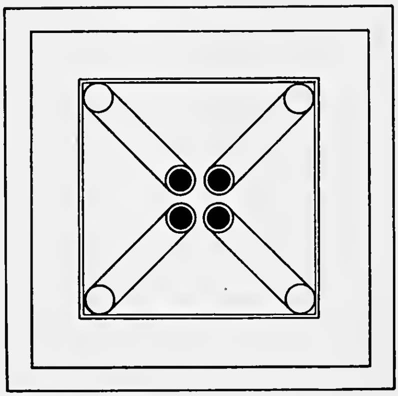


Plate XII.—The tri-trix puzzle. It is solved when all four shot are rolled into the four outer holes.

In the third case the learner may have at his disposal all the habits necessary to perform the act but because he does not know the proper sequence or coördination of the several habits he is forced to resort to trial-and-error learning. This is true in all cases of acquiring skill, whether of handwriting, skating, driving an automobile, using tools, or what not. A simple example may

be found in the mirror-drawing experiment. Take the one movement of tracing a line that appears in the mirror to go away from the body, diagonally to the right. And, to make the case still simpler, suppose that the learner knows that he must draw toward his body when the direction appears to be away from the body and that he must draw to the right when the direction appears to the right. Even then he will have to try and try before he will develop just the proper coördination of movements that are necessary to make the compound movement. But his random movements will be very slight as compared with one who does not understand the two components that make up his task. Here again it is the function of the teacher to eliminate as much trial and error learning as possible by leading the student to analyze his problem into its elements and work out the response to the elements one at a time. But no teacher can entirely eliminate random movements, for coördination comes only that way.

Stimulus Substitution.—New bonds can also be formed through stimulus substitution. In such cases there are present simultaneously, or in immediate succession, two stimuli followed by their responses. Repetition results in a bond being formed between S_1 and R_2, also between S_2 and R_1. Which of these two new bonds is primarily developed depends upon the set or attitude of the learner. (Refer to Lesson 11 for further discussion.)

Reorganization of Bonds

Here we are concerned primarily, not with the formation of new bonds, but in their rearrangement into new combinations. Most learning in school belongs here, particularly in the upper grades. From the standpoint of the results, three types of reorganization may be distinguished: i. e., (1) linking elements together through the use of old bonds (associative shifting), (2) short-circuiting, and (3) integration.

Associative shifting has been discussed in Lesson 11. Another example besides hund-hound-dog is the learning of an automobile license number, as, for example, 149,002 by associating it with the date Columbus discovered America with two (the same number as the last one in the license number) zeros before the

2. The whole process of thinking is largely a manipulating of associations that come to mind one after the other.

Short-circuiting can be illustrated in the case of saying the alphabet backwards. One individual's associations in response to the instructions to recite the alphabet backwards were: "last letter in alphabet"—"z"—"next to last letter"—"y"—"letter before y"—"xyz"—"letter before x"—"rstuvwx"—"w"—"rstuvw"—"v"—"rstuv"—"v," etc. As repetition after repetition continued the unnecessary steps were eliminated, or short-circuited, until finally the alphabet was recited backwards without a break. The above steps came to mind through associative shifting—through utilizing already existing bonds. The short-circuiting can be partly explained in terms of stimulus substitution as follows:—

Situation		Response
w	→	rstuvw
rstuvw	→	v
v	→	rstuv
rstuv	→	u

The repetition of almost any performance results in short-circuiting the unnecessary steps. And most of the improvement takes place without any consciousness of the changes. These changes are all the more likely to occur if we are attempting to improve the quality of the work or to cut down the time of doing it. If we are making no such effort, a minimum of short-circuiting results.

Integrations.—This topic is discussed later in Lesson 45. A simple illustration of what is meant by the term is sufficient at this point. A child develops certain responses to the sight of an apple, to the feel of it in his hands, to the smell of it, to the taste of it, and to the sound of eating it. As all these various stimuli and their responses occur together, the child develops many fusions of them whereby, if he sees, for example, the apple, he may react as though he had not only seen it, but had felt it, smelt it, tasted it, or had heard someone crunching it. One stimulus arouses in this way a complex response. The reader's response to "learning curve" is now a response that is an integration of many separate responses which have been more or less welded into one complete conception of the subject.

The Strengthening of Bonds

Bonds are strengthened by repetition, intensity, and the effect of satisfaction. They are weakened by lapse of time, interference, and the effect of dissatisfaction.

Efficient Memory

Efficient memory is dependent upon bonds sufficiently strong to function and the connecting up of what is to be remembered with situations that will occur when the response is desired.

What the Learning Process Means to Education

Evidently, *learning is connecting.* It is the forming of a bond between a situation and a response; the development of a habit. Clearly also, early in life the new connections will be slight modifications of reflex and instinctive actions; later the new connections may join great groups of complex habits together into such complicated processes as playing the piano or solving an original in geometry.

Teaching is, then, *the manipulation of the details making up the situations which confront children so that as they respond they will constantly form new habits and, moreover, habits that are desirable ones.* If the desired responses are new ones for the child then the learning must be of the "trial-and-error" type. But if the desired reponse is one that is already a response to another situation the new situation and old response can be connected together through associative shifting. For example, take the case of a boy learning to climb over a wooden fence. If he goes at it alone it will be largely a matter of "trial-and-error," because he will not analyze the entire performance into parts each of which he is already capable of doing. But if one who understands the movements to be made stands by and calls out "Now climb the ladder" he will make the movements previously associated with climbing a ladder. "Now put one leg over the top," he will respond by throwing one leg over the top board, as he has often done in climbing out of his crib. "Now cross your hands," "Now put the other leg over," "Now face me," "Now climb down," he will climb over the fence in a fairly smooth

and efficient way the first time. He does so because he has utilized old responses, one at a time, and he has utilized them because the old situations connected with them have been presented by the parent in the proper sequence. A little practice, then, results in connecting all of these responses together in a string just as the responses in saying each letter of the alphabet are connected together.

In what has gone before we have obtained a general conception of the learning process and of the mechanism by which situations become linked up with responses. In the lessons to follow we shall take up the matter of learning in greater detail. But the whole subject centers about this main theme just expressed, that the child's learning is conditioned by the skill the teacher displays in presenting situations to him. Lessons are difficult or easy depending not on the material of the lesson, ordinarily, but upon the order of presentation of the details in the lesson—an order depending upon what habits the child has already acquired.

Learning the characteristics of the learning process, as you are doing in this course, can be made by any particular author to fit any one of the types of learning. He can supply you with every detail in one, two, three order and expect you to memorize the material and through drill have you recite it as glibly as you do the alphabet. Or he can assign very indefinite problems and leave you to discover the elements and their order of relationship. The former, however, will not result in your obtaining a workable use of the material: the latter will take too long and is too discouraging, although if you do learn this way you have a wonderful grasp of the subject. Consequently, the present author prefers to introduce each topic by way of an experiment whereby you will have to work out the answers yourself. Then to follow the experiment with a discussion so that missing material may be identified and learned and the relationship of the various parts fully comprehended.

LESSON 19

MEASURING DIFFERENCES OF PERFORMANCE AMONG INDIVIDUALS—THE AVERAGE DEVIATION

The general characteristics of learning have now been presented. Differences between individuals have so far been ignored in our eagerness to discover the common principles found true of all individuals.

It is important to stop now and resurvey some of our material to see to what extent individuals are alike and to what extent they are different, and in what the differences consist.

In order to make these studies effectively it is necessary to become familiar with three mathematical conceptions, known as the "average deviation" (discussed in this lesson), the "normal curve of distribution" (Lesson 24), and the "coefficient of correlation" (Lesson 28).

All of these conceptions are basic to modern psychology, as well as to biology, sociology, economics, education, etc., and are worth understanding for their own sake, as well as for their use as tools in applying scientific principles to everyday problems.

The Average Deviation

Two fourth grade classes (A and B) were given the same test. The scores of the forty students were as follows:

Class A		Class B	
Pupils	Grades	Pupils	Grades
1	96	21	87
2	88	22	80
3	80	23	74
4	80	24	73
5	68	25	64
6	68	26	63
7	60	27	58
8	60	28	57
9	56	29	56
10	56	30	55
11	52	31	53
12	52	32	52
13	44	33	46
14	40	34	43
15	36	35	41
16	36	36	40
17	24	37	32
18	24	38	31
19	24	39	30
20	16	40	25
Total..........	1060		1060
Average........	53		53

When we average the twenty grades in each class we find the averages are the same, i. e., 53. But when we look over the scores we discover immediately that the two classes are not equal in performance. Class A has two students superior to any in Class B and four students inferior to the poorest in Class B. As far as this particular test is concerned it shows that the students in Class A are more unlike among themselves than are the students in Class B. In other words, there are greater differences in ability in Class A than Class B.

Such differences in ability in classes form an important consideration in the administration of a school. For the more homogeneous a class, the easier it is to handle. One of the duties of a principal is to assign pupils so as to have the smallest differences possible in a class. We shall come to appreciate this point more fully in the next few lessons.

It is clear that to state that Classes A and B have the same average is not sufficient. The total grades tell us another important point. But it is extremely awkward to have to reproduce in a report all of the grades of the pupils. Is there not some short-cut method by which these individual differences can be expressed?

It is just this that the "average deviation" gives us. It is a measurement used as a supplement to the average in studying individual differences. This measurement means exactly what the two words imply—the average amount of difference of the individuals making up the group from the average of the group as a whole. Consider carefully how it is obtained in the following examples (Table II). First, the average of the figures themselves is obtained. Second, the difference between the average and each separate figure is obtained. Third, the average of these differences or deviations is obtained. This is the average deviation (A. D.).

Knowing the average for each class and the average deviations, i. e.,

Class A—Average 53, A. D. 18.2
Class B—Average 53, A. D. 13.7

we can readily determine, if we do not have the original data, that there was a very great variation in the individuals. But of the two classes Class B is more homogeneous. We know now for certain that the average does not represent what all twenty pupils did. Far from it. Some must have varied above and below 53 by more than 18.2 (or in Class B more than 13.7) in order that the average of all the deviations should be 18.2.

It is mathematically true that very few cases will ever differ from the average by more than three times the A. D. For example, it is unlikely we would have pupils in Class A with grades higher than $53 + (3 \times 18.2)$ or 107.6, or lower than $53 - (3 \times 18.2)$ or -1.6; and in Class B higher than $53 + (3 \times 13.7)$ or 94.1, or lower than $53 - (3 \times 13.7)$, or 11.9. In these particular classes we do not have any cases varying as much as these limits.

Table II.—Illustrating the Method of Obtaining the Average Deviation (A. D.)

The left hand of the table illustrates the work, involved in obtaining the A. D. of the grades of the 20 pupils in Class A, while the right half of the table shows similarly the work involved in obtaining the A. D. grades in Class B.

Class A			Class B		
Pupils	Scores	Differences	Pupils	Scores	Differences
1	96	96 − 53 = 43	21	87	87 − 53 = 34
2	88	88 − 53 = 35	22	80	80 − 53 = 27
3	80	80 − 53 = 27	23	74	74 − 53 = 21
4	80	80 − 53 = 27	24	73	73 − 53 = 20
5	68	68 − 53 = 15	25	64	64 − 53 = 11
6	68	68 − 53 = 15	26	63	63 − 53 = 10
7	60	60 − 53 = 7	27	58	58 − 53 = 5
8	60	60 − 53 = 7	28	57	57 − 53 = 4
9	56	56 − 53 = 3	29	56	56 − 53 = 3
10	56	56 − 53 = 3	30	55	55 − 53 = 2
11	52	53 − 52 = 1	31	53	53 − 53 = 0
12	52	53 − 52 = 1	32	52	53 − 52 = 1
13	44	53 − 44 = 9	33	46	53 − 46 = 7
14	40	53 − 40 = 13	34	43	53 − 43 = 10
15	36	53 − 36 = 17	35	41	53 − 41 = 12
16	36	53 − 36 = 17	36	40	53 − 40 = 13
17	24	53 − 24 = 29	37	32	53 − 32 = 21
18	24	53 − 24 = 29	38	31	53 − 31 = 22
19	24	53 − 24 = 29	39	30	53 − 30 = 23
20	16	53 − 16 = 37	40	25	53 − 25 = 28
Total...	1060	364		1060	274
Av......	53	18.2		53	13.7
The A. D. is 18.2—the average of the differences (deviations).			The A. D. is 13.7—the average of the differences (deviations).		

Problems

Find the A. D. of the grades in the following classes:

1. Class C is composed of pupils 1, 3, 5, 7, 9, 11, 13, 15, 17, and 19 in Class A given above.
2. Class D is composed of pupils 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20.
3. Class E is composed of pupils 1 to 5, and 16 to 20.
4. Class F is composed of pupils 6 to 15, inclusive.

Check your answers with the instructor at the next class-hour. If incorrect spend part of that hour making sure you understand how to get an A. D.

NOTE.—Bring coördinate paper with you to the next class-hour.

LESSON 20

HOW DO INDIVIDUALS DIFFER IN LEARNING MIRROR-DRAWING?

We have so far studied a number of learning curves. We have discovered some general facts about the process of learning—about the process of learning taken on the average. But it is worth while to stop and consider whether all individuals learn in the same way.

We know that people differ. We know that they differ in the way they do a certain lesson, that they differ in the time it takes them to learn the lesson, in the way they answer questions about the lesson, etc. We know some get good marks and some get poor marks. Why are there all these differences? What are the causes of individual differences?

Let us consider just one of these problems. Let us study the data from 10 individuals in the mirror-drawing experiment and see in what respects they are alike and in what respects they are different.

Below are given the results of ten individuals (called A to J) in the mirror-drawing experiment. The records are a combination of their time and error data. Endeavor to discover by yourself, together with the help of your partner, as many ways as you can in which these records are (1) alike and (2) different. That is, exactly what are the characteristics which are common to the learning of these ten individuals and, on the other hand, in what respects do the records of their learning differ?

The Use of Tables of Statistics versus Curves.—When confronted with many figures as in Table III, one should endeavor by some means or other to present them in a diagram or set of curves. No one can grasp the significance of a complex set of figures from studying the figures themselves with anywhere near the ease that he can from seeing those same figures set forth in curves. In general, curves should be used for discovering or for presenting general relationships, while tables should be used when the facts need to be ascertained very accurately.

TABLE III.—RECORDS OF TEN DIFFERENT INDIVIDUALS (A—J) IN MIRROR-DRAWING EXPERIMENT[1]

Trials	A	B	C	D	E	F	G	H	I	J	Average
1	232	76	210	363	216	286	283	701	129	131	263
2	193	77	152	167	147	144	148	184	94	90	140
3	157	80	115	128	160	109	69	148	98	75	114
4	115	68	108	143	113	141	66	144	91	67	106
5	133	70	108	132	110	97	76	98	84	75	98
6	88	57	115	125	103	99	59	90	69	64	87
7	87	65	96	121	90	97	50	87	67	67	83
8	90	62	92	149	91	111	53	81	75	51	86
9	102	65	62	140	92	101	48	79	70	49	81
10	88	54	71	121	75	89	56	72	55	49	73
11	102	59	68	121	90	115	56	71	66	51	80
12	88	63	59	112	74	87	51	58	57	55	70
13	87	51	56	95	64	90	50	63	55	47	66
14	79	57	58	95	70	87	44	56	59	46	65
15	89	53	60	86	75	81	43	55	59	38	64
16	64	48	55	114	59	84	38	54	51	44	61
17	68	46	61	100	62	81	36	54	59	43	61
18	71	37	53	116	59	71	43	62	54	30	60
19	55	49	42	122	51	69	40	53	52	31	56
20	61	50	58	85	52	70	35	60	40	36	55

THE ASSIGNMENT

First of all, then, plot the ten sets of figures. Two or three curves can be drawn on the same sheet of paper.

Now from a study of your curves and your table ascertain whether all ten agree or disagree on the following points:

1. Do they show improvement with practice?
2. Do they show the same initial efficiency?
3. Do they show the same final efficiency?

[1] The data presented here were actually obtained from ten individuals. The individuals have been so selected, however, that the conclusions obtained from these data will agree very closely with similar calculations based on a study of 56 individuals. The averages obtained from 56 men and women are respectively:—242, 159, 137, 120, 114, 99, 94, 86, 88, 83 79, 76, 74, 74, 70, 70, 68, 64, 64, 63.

Each figure represents the time consumed in doing the drawing plus the, number of errors that were made in that drawing.

4. Is a greater gain made during the first five trials than during the last five?
5. Is progress regular or irregular?
6. Do all curves show an equal gain?

Back up each of your assertions with proof from your data.

Second, if we should arrange the ten individuals according to their initial ability in this performance we would have them in this order: B(76), I(129), J(131), C(210), E(216), A(232), G(283), F(286), D(363), and H(701). Copy this order onto a sheet of paper so that the letters will appear in a column one under the other. Now arrange the ten individuals according to their final ability in this performance in a similar column. Study the relationship between the two columns of letters and then decide whether individuals who are best at the start are best at the end or not. Does your conclusion hold good for all ten or for only the majority? If you have exceptions to your rule, can you explain why there should be these exceptions? Make a further comparison (a) between the order of proficiency at the start and the order at the tenth trial, and (b) between the order at the tenth trial and the order at the last trial.

Do you think that B, who is best at the start and fourth at the end, and I, who was second at the start and third at the end, will do better, equal to, or poorer than D and H in arithmetic, geography, running a grocery store, or driving a plow? Explain. What significance, if any, do you think there is in the superiority of B and I over D and H in this performance? How would G compare in these respects with the four (i. e., B, I, D and H)?

Hand in your report at the next class-hour, written up in the usual manner.

LESSON 21

INTRODUCTION TO THE GENERAL SUBJECT OF INDIVIDUAL DIFFERENCES

Individuals differ very materially with respect to every human trait. If we compare them with respect to height, or weight, or muscular strength, or lung capacity, or eyesight, or hearing, or color of hair, or spelling ability, or musical ability, or inventive power, or any other trait, we find that they all differ from one another in these respects. When one is at first confronted with all these differences one is very apt to become utterly confused and feel that there is no order at all in this chaos of human differences. The person who is the tallest is not always the heaviest. In fact, he may be very thin and weigh comparatively little. The person who has the best eyesight may have any color of hair and may have very good or very poor hearing. The musician may also be a poet or he may be unable to express himself very clearly in any way except on his musical instrument.

Still as we progress in our study of these differences we come to see that all is not chaos, that there is some system underlying the matter. As yet science has worked out but few of the great laws involved. But a start has been made, and already we have been helped in understanding the peculiarities of our friends and pupils.

There is no more important subject for the teacher in psychology than this subject of individual differences. If we were all alike then teaching would be a comparatively easy subject. We would need to know just the physical, mental, and moral dimensions and requirements of the standard and then devise one set of methods which would fit in every case and inevitably produce good spellers, writers, etc. But people are not alike. And this fact means that no one method will work with every individual. Methods of teaching when applied to certain

children will produce the desired result and when applied to other children will produce no result worth while or possibly just the opposite result from that desired. Undoubtedly some of the children who fail in the 4th Grade fail because the wrong methods were applied to them. If other methods had been applied some of these failures would have succeeded but, on the other hand, some of those who succeeded would then have failed. What is needed today is that teachers become expert in understanding the differences in children and so be able to apply intelligently varying methods to varying needs. Without doubt the teacher of the future is going to become a diagnostician in much the same way that a physician is. The latter studies symptoms, diagnoses the diseases, prescribes the treatment, and if he is fortunate directs that treatment until the patient is cured. The teacher of the future will be one who will understand the peculiarities of children and on the basis of these peculiarities or differences diagnose the reason as to why the child is not developing properly, prescribe the treatment, and carry it out to a successful end. This is exactly what is now being attempted in our special classes for the defective. And although possibly it is easier to do this with defectives than with normal children, yet society cannot permit the poorest and most worthless one-tenth of our children to have a better type of teaching than that given to the remainder, who will have to carry not only their own burdens, but also a large share of the burdens of the defective class.

Now let us turn and consider such facts and principles as we can discover concerning individual differences.

Individual Differences, Based on Mirror-drawing Experiment

It is clear from a study of the learning curves of the ten individuals recorded in Lesson 20 that they all agree in that:—

1. They show improvement with practice.

2. They make greater gain at the start than at the end of the practice.

3. They progress irregularly, i. e., they do not always advance but sometimes do more poorly than in the preceding trial. We shall find after studying many examples of learning that these

three facts remain true. Even though individuals differ tremendously, yet they do not differ as regards these respects. *Continued practice does produce improvement in a performance in the long run, but it may not be apparent when two or three or even more successive trials are alone compared. Improvement is also greater at the start of practice than at the end.*

On the other hand, individuals differ as regards:—

1. Initial efficiency.
2. Final efficiency.
3. Amount of improvement.

This is clear from the data in Table III. It will be found to be true when any set of data is studied.

The Use of the Average as a Measure of a Group

We can obtain an *average* from the records of a large or small number of individuals. Such an average record is given in the last column of Table III. When we study this average record from ten individuals we realize that it is an expression of the entire ten records. But it is not typical of what any one person would do. No one of the ten did the mirror-drawing in 263 units (of time and accuracy combined). The nearest to this record was G, who did the experiment in 283 units, differing thereby from the average by 20 units. On the other hand, B (the best of the ten) beat this average by 187 units, and H (the poorest of the ten) was poorer than the average by 438 units. Clearly a great many interesting facts are covered up or lost by referring to the average as an expression of what this group of ten individuals could do. By knowing only that the group averaged 263 units for its first trial we would have no knowledge of how much the ten had differed or varied from each other.

We have come also to realize that any individual learning curve is not perfectly smooth but has a great variety of fluctuations in it. In other words, although a person may be progressing, his successive performances may not necessarily show this. Sometimes he gains, sometimes he loses, but on the whole he is advancing. Now our average record of the ten individuals in the mirror-drawing experiment is singularly free from such fluctuations. Only twice does the curve rise (show decrease in efficiency) and then only for slight amounts. From a study of

the average curve we would be led to the false notion that improvement is very steady and even. But such, we realize, is not the case. Evidently, then, the average, although very useful, is not a sufficient measure of a class performance to tell us all that we need to know about that class.

Consider another example taken from a survey of the Demonstration School of George Peabody College for Teachers.[1]

All of the children in Grades IV to VIII were tested with the *Kansas Silent Reading Test.* This test consists of a number of paragraphs like the following:—

No. 1

VALUE 1.0 — The air near the ceiling of a room is warm, while that on the floor is cold. Two boys are in the room, James on the floor and Harry on a box eight feet high. Which boy has the warmer place?

....

No. 2

VALUE 1.3 — If gray is darker than white and black is darker than gray, what color of those named in this sentence is lighter than gray?

....

No. 3

VALUE 1.6 — We can see through glass, so we call it transparent. We cannot see through iron, so we call it opaque. Is black ink opaque, or is it transparent?

....

The children are allowed five minutes in which to read over as many of these paragraphs as they can and to execute the directions in each. They are scored in terms of the paragraphs to which they have correctly reacted, each paragraph counting proportionately to its determined difficulty or value.

In Table IV are presented the average scores of the five grades, together with the *norms* for those grades. A norm is a standard set for a grade after testing thousands of children so as to know exactly what the average is. From these figures it is clear that with respect to this method of testing silent reading the children in the five grades are superior to children throughout the country

[1] C. C. Denny. *The Peabody Demonstration School in the Light of Standard Tests.* Unpublished thesis in the library of George Peabody College for Teachers.

as in all the grades except VII the average of the grade is superior to the norm and in Grade VII the figures are equal to the norm.

Table IV.—Average Scores and Norms, Grades IV to VIII

Kansas Silent Reading Scale

Grades	IV	V	VI	VII	VIII
Averages....................	13.0	15.7	16.8	16.5	23.4
Norms......................	9.4	13.4	13.8	16.5	19.2

As has been said the averages "show the school to be in most excellent condition." However, if this is all that the class-room teacher is to learn from the test, the very knowledge that should enable her to give her pupils, as individuals, the best possible instruction will have been missed. The scores, in rank order, of all the pupils in the various grades are shown in Table V. The data given in this table show some astounding individual differences. For instance, the lowest score in the fourth grade is less than one-sixth of the highest score in the same grade; 60% of all the pupils in the fourth grade made a better score than the poorest score in the eighth grade; 17% of all the pupils in the fourth grade made a better score than the norm for the eighth grade; while all the pupils, except six, in the fourth grade made a better score than the lowest score in the seventh grade. In general, the highest score made in each grade is approximately 200% of the norm for that grade; while in three grades, IV, V, and VII, the lowest score is less than half the norm.

"Since reading is fundamental and basic to most of the other studies in the school, this wide variation in individual scores indicates the complexity of the problem confronting the class-room teacher. Why did the poorest fourth grade pupil make only a score of 3.9, and the best one make 24? Is one endowed by nature with six times as much reading power as the other? Did the form and manner of instruction in reading fit one six times as well as the other? Or is the wide difference due to other causes? The facts of Table V raise innumerable administrative problems. If the school is to be organized so that each individual pupil may get greatest good from the instruction given, teacher, principal, superintendent, school board, and community must realize this wide variation and coöperate in the organization and administration of a system which takes individual differences into consideration."

TABLE V.—INDIVIDUAL SCORES BY RANK ORDER, GRADES IV TO VIII
Kansas Silent Reading Test
Grades

Pupil	IV	V	VI	VII	VIII
1	24.0	28.1	34.6	32.6	34.6
2	21.7	25.4	32.2	28.3	34.6
3	20.3	23.3	26.3	24.1	31.6
4	19.9	22.3	24.0	22.3	31.6
5	19.7	22.3	23.4	21.3	30.3
6	18.4	21.4	22.5	20.7	28.3
7	16.7	21.4	22.3	20.0	27.3
8	16.7	19.7	21.0	19.3	26.3
9	15.5	19.3	20.1	18.5	22.3
10	15.1	18.4	19.1	17.7	21.7
11	15.0	18.3	18.4	17.7	20.7
12	14.8	17.3	18.1	17.7	19.7
13	14.4	17.1	17.5	17.4	18.6
14	13.4	16.1	16.1	17.1	18.4
15	13.1	16.1	14.8	16.1	15.4
16	12.8	15.8	14.8	15.8	13.8
17	12.8	15.4	14.4	15.7	13.0
18	12.5	13.4	14.4	15.1	12.3
19	11.3	13.4	14.3	14.1	
20	11.2	12.9	13.8	13.2	
21	10.4	12.6	13.5	11.5	
22	9.0	12.4	13.4	11.2	
23	9.0	12.4	13.2	10.6	
24	8.9	12.2	12.8	10.6	
25	6.2	11.7	11.1	8.8	
26	6.2	10.6	10.9	8.8	
27	6.2	10.6	10.7	8.8	
28	6.2	8.9	9.1	8.1	
29	5.7	8.7	8.5		
30	3.9	8.5	8.4		
31		8.5	8.1		
32		6.3			
Average	13.0	15.7	16.8	16.5	23.4

THE USE OF THE A. D. AS A MEASURE OF INDIVIDUAL DIFFERENCES

We have seen thus far that the average is not a sufficient measure for presenting the proficiency of a group of individuals.

And in Lesson 19 some of the advantages of the average deviation were presented. The subject warrants further consideration.

The average of the initial trials in the case of the ten individuals recorded in Table III is 263; the average deviation is 118. The average of the final trials is 55 and the average deviation 12. Knowing the A. D. as well as the average for the initial and final trials in the mirror-drawing experiment we can readily determine, if we do not have the original data, that there was a very great variation in the individuals at the start, and still considerable difference in their proficiency at the end of the practice. We know that the ten individuals differed on the average 118 units from the average of 263 units. We know now for certain that the average does not represent what all ten individuals did. Far from it. Some must have varied above and below 263 by more than 118 in order that the average of all the deviations should be 118. On the other hand we can tell, by knowing that the final trial averaged 55 with an A. D. of 12, that the ten must all be fairly close to the average, probably none varying more than three times the A. D. or by more than 36. That is, no record would probably be better than 19 (55 − 36) or poorer than 91 (55 + 36). (As an actual fact among 56 men and women the best record has been 33 (55 − 2 times the A. D.) and the poorest was 118 (55 + 5 times the A. D.). But there are only two records in the 56 which are poorer than three times the A. D. (i. e., 91)—one being the 118 already referred to and the other being 93.)

In a similar way the A. D. may be determined for the data in Table V concerning the silent reading ability of children in the five grades. We then have:—

Av. Score, Silent Reading........	Grade IV	13.0	A. D.	**4.2**
Av. Score, Silent Reading........	Grade V	15.7	A. D.	**4.5**
Av. Score, Silent Reading........	Grade VI	16.8	A. D.	**5.3**
Av. Score, Silent Reading........	Grade VII	16.5	A. D.	**4.5**
Av. Score, Silent Reading........	Grade VIII	23.4	A. D.	**6.4**

The presence of these average deviations helps us considerably in estimating how much the various children in the two classes differ from their average.

The more one uses this measure—the A. D.—the more it comes to mean; but still it never does tell as much as one can

read from the original data themselves when displayed in tabular form as in Table V.

Relationship of Initial and Final Ability

When the ten individuals are arranged in "order of merit" according to initial and final ability it is clear that on the whole those who are best at the start are best at the end. G is markedly an exception to the rule, starting at sixth place and ending first. H also gains four places, progressing from tenth to sixth place. G was actually a student of markedly superior ability, but noted for awkwardness of movement. He tackled the experiment with misgivings as to his ability to do it thinking it was largely a feat of arm movement. He learned very rapidly and surprised himself with his performance.

Knowing nothing of these ten individuals but their initial scores, it would be safer to hire the first two to work in a store or on a farm, than the last two. This is true, because the test does measure general ability to some extent. But because the test is far from a perfect measure of ability, individuals hired on the basis of it would not always come up to expectations. This we see in the case of G, who, on the basis of the final score, is better than either B or I.

LESSON 22

HOW DO DIFFERENT GROUPS OF INDIVIDUALS DIFFER WITH RESPECT TO LEARNING SIMPLE ARITHMETICAL COMBINATIONS?

In this lesson we shall devote our attention to how individuals differ in the simplest processes of arithmetic, i. e., simple addition and simple multiplication. Some of the questions involved are: How do I differ from other adults in a working knowledge of the multiplication table? Am I more or less rapid in my work than the average adult? Am I more or less accurate than the average adult? How do adults differ from children in these respects? How do children differ among themselves? Besides ascertaining some of the facts in these cases, we shall commence to ask ourselves the further question—what is the cause of these differences?

First of all the members of the laboratory section will use the B-Test blank, on which appears eighty simple problems in addition, such as $\begin{array}{r}4\\ \underline{7}\end{array}$ $\begin{array}{r}1\\ \underline{3}\end{array}$, etc. The class will be given one minute in which to do as many of these problems as they can do. After that the class will be tested as to their proficiency in multiplication, using the BX-Test blank. The papers will then be scored and the averages and average deviations of the two tests worked out for the class. When that is finished the laboratory pairs will proceed as usual by themselves, taking up the various parts of the assignment in order and doing as much as they can during the remainder of the hour. As each part is finished it will be advisable for the members of the class to consult with the instructor in order to make sure that they have understood the instructions and have executed them properly.

Problem.—How do adults differ as to their ability to solve simple addition and multiplication problems?

Apparatus.—A B-Test and a BX-Test blank, watch.

Procedure.—When all in the laboratory section are ready, turn face down the page on which the B-Test is given. The instructor

will give two signals, "Get Ready," and "Go." At the latter signal, turn the sheet over and solve as many problems as you can during the one minute allowed you. At the signal, "Stop," *stop* your work wherever you are and hold up your right hand, so that the instructor can have visible proof that you have actually stopped. (These instructions you will undoubtedly have cause to use later on yourself, as a teacher. You now have an opportunity to know how it feels to take a test of this sort.)

B TEST—ADDITION

Name.............................Age.......Grade...............

3 11 —	0 8 —	3 2 —	11 7 —	12 4 —	9 0 —	7 8 —	6 5 —	4 8 —	2 1 —
8 12 —	5 1 —	8 0 —	12 5 —	6 10 —	9 5 —	2 10 —	11 3 —	12 1 —	0 7 —
1 8 —	10 7 —	4 12 —	9 1 —	6 6 —	7 3 —	12 9 —	1 4 —	7 12 —	6 1 —
7 2 —	6 11 —	4 7 —	9 6 —	10 3 —	2 6 —	1 9 —	10 6 —	8 3 —	5 10 —
0 3 —	8 4 —	10 10 —	7 11 —	3 3 —	6 2 —	5 5 —	4 3 —	8 5 —	3 6 —
11 4 —	7 7 —	0 11 —	9 10 —	11 11 —	4 0 —	8 8 —	5 4 —	8 9 —	6 7 —
3 12 —	10 1 —	3 7 —	0 2 —	12 8 —	1 5 —	9 9 —	1 0 —	4 9 —	5 0 —
12 11 —	5 9 —	2 2 —	11 8 —	2 5 —	0 12 —	2 11 —	4 4 —	10 11 —	2 9 —

BX-Test—Multiplication

Name.................................Age.................Grade.....

3	0	3	11	12	9	7	6	4	2
11	8	2	7	4	0	8	5	8	1
—	—	—	—	—	—	—	—	—	—
8	5	8	12	6	9	2	11	12	0
12	1	0	5	10	5	10	3	1	7
—	—	—	—	—	—	—	—	—	—
1	10	4	9	6	7	12	1	7	6
8	7	12	1	6	3	9	4	12	1
—	—	—	—	—	—	—	—	—	—
7	6	4	9	10	2	1	10	8	5
2	11	7	6	3	6	9	6	3	10
—	—	—	—	—	—	—	—	—	—
0	8	10	7	3	6	5	4	8	3
3	4	10	11	3	2	5	3	5	6
—	—	—	—	—	—	—	—	—	—
11	7	0	9	11	4	8	5	8	6
4	7	11	10	11	0	8	4	9	7
—	—	—	—	—	—	—	—	—	—
3	10	3	0	12	1	9	1	4	5
12	1	7	2	8	5	9	0	9	0
—	—	—	—	—	—	—	—	—	—
12	5	2	11	2	0	2	4	10	2
11	9	2	8	5	12	11	4	11	9
—	—	—	—	—	—	—	—	—	—

Trade papers with some other member of the class. The instructor will then call out the correct answers to the addition problems. Every mistake on the paper before you should be indicated by drawing a conspicuous circle around it. Indicate at the top of the page the total number of problems performed, the number incorrect, and the number correct. A convenient form for doing this, "65 – 3 = 62," or "60 – 0 = 60," where the first number indicates the number performed, the second the number wrong, and the third the number correct.

Return the papers to their owners, who then may look them over to see if they have been corrected properly. In case of a controversy the scorer should be the final judge. Ambiguously written figures should be scored against.

Repeat the above with the BX-Test blank to test ability in simple multiplication.

Results.—The instructor will now record the data of the two tests on the board and with the aid of the class determine the averages and average deviations of the class. Any errors characteristic of the class should also be recorded.

Interpretation and Application.—Combine into one general discussion at the close of your report the interpretations and applications to this problem and those that follow.

Part No. 2

Problem.—How do adults differ from 4th Grade children in their ability to solve simple multiplication and addition problems?

Apparatus.—The data in Table VI.

Table VI.—Showing Average Number of Addition and Multiplication Problems Solved Correctly in One Minute by Adults and 4th Grade Children in 10 (and 14) Trials on Different Days

Trials	Addition (B-test)		Multiplication (BX-test)	
	Adults	4th Grade Children	Adults	4th Grade Children
1	59	19	40	11
2	67	21	50	15
3	69	22	52	16
4	69	23	55	17
5	71	25	58	19
6	72	26	61	20
7	74	27	61	21
8	75	28	62	21
9	75	29	64	23
10	76	30	64	24
11		31		25
12		32		26
13		32		27
14		33		28

Note.—The children were allowed two minutes instead of one minute to work at the blank. Their records are expressed in terms of what they did in 1 minute i. e., half of their 2-minute record.

Procedure and Results.—Plot these data. Arrange your vertical scale so that it will extend from 0 to 80. Connect the points on the addition curves with a solid line, and the points on the multiplication curves with a dotted line.

Part No. 3

Problem.—How do normal 4th Grade children differ from badly retarded children of the same age in their ability to solve simple addition problems?

Apparatus.—The data in Table VI and the following information: A class of 2B Grade children were tested by M. Phillips with the B-Test. These children averaged 9½ years (just what the usual 4th Grade averages). They had repeated the work of the first and second grades several times and were considered by the authorities to be practically hopeless. They were put (1) through the B-Test on ten successive days; (2) through the C-Test (identical to the B-Test except for the combinations which were new) on ten more days; (3) given 10 minutes drill on 15 successive days on the problems of the B-Test; and (4) again given the B-Test for 10 successive days. Parts (2) and (3) represent 170 minutes drill devoted to simple addition problems distributed over 25 days. The average records of the class in parts (1) and (4) with the B-Test are as follows:—

Trials	Part 1	Part 4
1	4	7
2	5	8
3	5	8
4	5	9
5	6	9
6	6	10
7	6	10
8	6	10
9	7	11
10	7	11

Procedure, Etc.—Handle these data as in Part 2. Bear in mind that the averages (i. e., *norms*) for a Demonstration School and for adults were as follows:

Grades	Norms in Addition (B-Test) Oct., 1915	Feb., 1917	Norms in Multiplication (BX-Test) Oct., 1915	Feb., 1917
III	..	15	..	6
IV	19	29	11	20
V	26	37	17	26
VI	..	40	..	25
VII	18	44	27	27
VIII	20	43	30	30
IX	..	49	..	30
Adults....	59	59	40	40

The differences in the norms on the two different dates is due, first to the fact that in the second case the grades had had three months more schooling by February than in October and, second, to the fact that during the interval a considerable amount of time was spent in the school speeding the children up. That this was very much needed is clearly apparent from the figures. In justice to the Demonstration School it should be noted here that the first set of norms was taken very shortly after the opening of the school and the poor work represented the training these children had received prior to entering the school.

Procedure and Results.—Plot the learning curves of the mentally defective children on the same graph as your other curves.

Note: In these experiments the same blank was used each day. Some of the learning consists in more or less learning of answers in a regular order. If a different arrangement of the little problems had been presented each time, the curves would not have gone up so rapidly.

Interpretation of the Three Parts to This Problem.—What do you deduce as to how various classes of individuals differ with respect to learning simple addition and multiplication combinations? Have these three groups of individuals become more or less alike as the result of ten days' practice? What effect has this fact upon our present plan of school administration?

Application.—Hand in your report at the next class-hour.

LESSON 23

THE THREE CAUSES OF INDIVIDUAL DIFFERENCES—ENVIRONMENT, HEREDITY, AND TRAINING

We have noted already that all individuals are alike in that they profit by practice; that they show greater gain at the beginning of practice than at any later time; and that the rate of improvement is irregular, an individual showing remarkable gains with certain trials and equally surprising "slumps" with other trials. We have also noted that individuals differ as to (1) initial performance, (2) final performance, and (3) the amount of improvement resulting from any given amount of practice. Let us now consider these differences in greater detail.

Environment, Heredity and Training

A human being may be thought of, first of all, as being produced by the two factors—*heredity* and *environment.* He is a living organism that *reacts* to the *stimuli* that confront him in life. The stimuli (environment) are the immediate cause of his reactions—*they initiate the reaction but they do not condition that reaction.* In other words, the environment brings about reactions but what those reactions are are determined by the laws of the organism itself. What a person does during any day of his life is determined by his environment, then, and by his innate life. If it is summer time and there is a swimming hole in the vicinity, he may or may not go swimming. If there is no other factor in his environment, such as a dance, to lead him to do otherwise, he quite likely will go swimming. Yet he may not. Some individuals do not respond to a swimming stimulus by going in swimming. Their natures are so constituted that they do not receive pleasure from such experience and so do not seek it. One of the writer's boyhood friends—the best pitcher in town—never went swimming. He didn't enjoy it. In the Holmgren test for color blindness one is given a hundred or more different colored skeins of yarn. He is then given a large skein

of red yarn and told to pick out all the little skeins of similar color. The ordinary individual picks out only red skeins. But a color-blind person picks out not only red but also brown and gray skeins. And if there happens to be a green skein of the same brightness as his red standard he will pick this out also. The same stimulus leads to two quite different reactions here. The reactions are different because of the difference in the development of the eyes of the two individuals. The eyes of one individual are so constituted that red and green are distinguished apart; the eyes of the other individual are so constituted that red, gray, and brown, and even a green, with the correct brightness, appear alike. We may say then again, that the stimulus (environment) is the immediate cause of a reaction, but the innate make-up of the individual (heredity) determines what the reaction shall be.

In the case of our mirror-drawing experiment, the stimulus was the same for all ten individuals, but their reactions differed very materially. Some were very accurate and quick in reacting, some were accurate and slow, some were inaccurate but quick, and some were inaccurate and slow. At first thought we might imagine that the individual differences in this experiment were all due to heredity, since the stimulus was alike for the ten individuals. But such a statement is not so exact as we shall desire here. Suppose one of the ten individuals had practiced with the apparatus at some previous time. Would it then be fair to say that he did better than the others simply because of heredity? Certainly not. We must then introduce a third factor into the discussion—the factor of *training*. Training may be thought of in this connection as the habits the individual has accumulated from previous experiences in life. Every time we react to a stimulus we add a new element to our mental make-up. And so we may think of ourselves as being made up of pure hereditary influences plus habitual influences. How we react, then, toward the swimming hole stimulus is dependent (1) upon the entire stimulus comprising swimming hole, dancing possibilities, etc.; (2) upon our original nature given us by heredity, and (3) upon the sum total of our experiences in life, our training. This factor of training is, of course, a mixture of heredity and previous environment which now affects the organism's reaction to his immediate environment.

Consider the case of a baby who has commenced to talk and already knows a "goose" but no other bird, and the word "dress" but none other to designate clothing. Standing on the porch one day, she observes a pigeon up above her preening its feathers. Finally a feather drops out and flutters to her feet. She picks it up and holding it out to her mother to admire, exclaims, "Goose's dress." The reaction, "Goose's dress," is then initiated by the feather falling at her feet. Original nature is responsible for the responding to the small object by picking it up, also by desiring to talk about it. But previous training determines that the particular words that are used are words already learned. All three factors contribute then to the reaction. *What we do at any moment in life is due to the interplay of these three factors:* (1) *the stimulus confronting us;* (2) *our own original nature inherited from our ancestors, and* (3) *our own acquired habits, the result of previous experiences.*

Before considering the individual differences which we have discovered in the mirror-drawing experiment, or the simple arithmetical work, in the light of these three factors, one point needs to be cleared up which may puzzle some.

Learning Curves Based on "Time" versus Those Based on "Amount Done"

In the mirror-drawing learning curves, as one progressed, his curve came down; in the arithmetic test, as one improved, his curve went up. This difference is due to the fact that in the mirror-drawing experiment the results were recorded in terms of *time* (seconds), while in the arithmetic tests the results were recorded in terms of *amount done.* Improvement shows itself either by a decrease in time for doing the same task (as in the mirror-drawing experiment) or by an increase in what is accomplished in the same work-period (as in the arithmetic tests). Now either of these curves can be transmuted so as to appear in the other form. Take, for example, the curve of learning of the 4th Grade children in multiplication (shown in the left-hand curve of Plate XIII). Here we see that the children performed 11 problems correctly on the first occasion, 15.5 problems on the second, etc. They accomplished that much in 60 seconds. At that rate it required 5.5 seconds to do one problem on the first

occasion (i. e., 60 ÷ 11 = 5.5); 3.9 seconds to do one problem on the second occasion (i. e., 60 ÷ 15.5 = 3.9); etc. When these quotients are plotted for the trials we obtain the right-hand curve in Plate XIII. The two curves, then, both record the same facts, although one goes up and the other comes down. With a little practice in thinking in terms of curves this seeming paradox will no longer bother one.

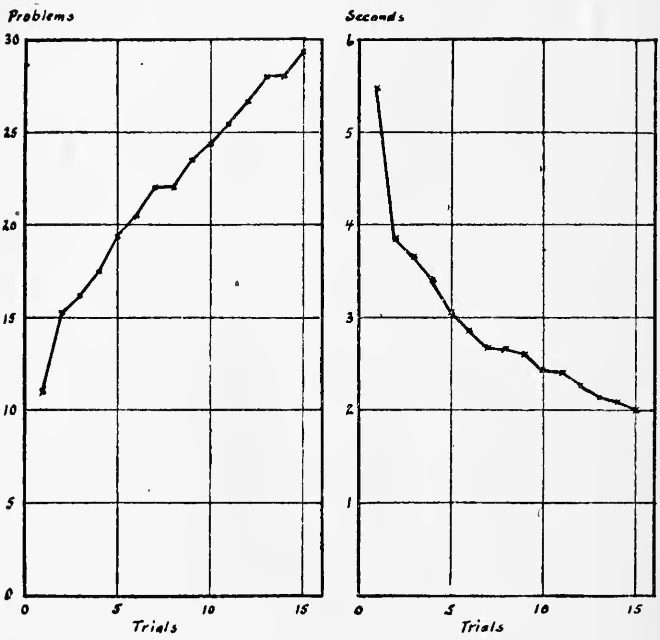


Plate XIII.—Learning curves of 4th Grade children in multiplication. The left hand curve shows the number of problems solved in two minutes on 15 different days. The right hand curve shows the average time required to do a single problem on the 15 different days. The former records progress in *amount* done, the latter in *time* consumed.

Explanation of Individual Differences in Terms of "Heredity" and "Training"

In the case of the mirror-drawing experiment, or the simple arithmetical work, the stimuli are the same for all the individuals. All the individuals are confronted with the same apparatus or the same blank of 80 problems. In one sense this is not strictly true, as we have already seen, since different individuals respond

to different details in a complex situation. But these differences are not due to actual physical differences in the stimulus, but rather to differences in the individuals themselves. We may then properly speak of the stimuli confronting the individuals as being exactly the same in all ten cases. It then remains to explain the differences in the responses made by ten individuals in terms of "original nature" or "training."

The Effect of Previous Training.—We have learned that all individuals show greater improvement at the commencement of practice than at the end. This being the case *the learning curves of those who have had no previous practice will rise more rapidly and slow up more gradually than in the case of those who have had previous practice.*

This fact may be illustrated in Plate XIV by saying that the person who has had no previous practice (training) would have the learning curve marked B. The person with previous training might have instead a curve similar to A. The former's curve would show very marked gains at the start and would show a large improvement altogether. The latter's curve would not show such a marked gain at the start and would not show such a large total improvement. We may think of A's curve as not being complete—that the first 15 trials are not shown here (have ing been performed before) and that what is represented is trials 16 to 41. This is on the assumption that A and B are exactly identical in every respect. This is further shown in the two curves by representing B's progress in trials 16 to 26 as exactly equal to A's progress in trials 1 to 11. And if the curves were continued, B's progress in trials 26 to 41 would be identical to A's records in trials 11 to 26. *Previous training, then, affects an individual's learning curve by raising its starting-point and by eliminating to some extent at least the ordinary big rise at the start.*

It was stated above that B would show *apparently* greater improvement than A. The word "apparently" should be emphasized. Plate XIV is so drawn as to indicate that although B's curve shows a greater gain than A's curve when measured in terms of improvement in problems performed correctly (i. e., 5 problems to 33.0 problems as against 29.2 problems to 35.9 problems), yet in terms of number of trials B has not gained over A. B started out 15 trials behind and remained 15 trials behind to the end. If B's curve were extended for 15 trials more it

would then reach the point reached by A at his 41st trial—the end of his practice period. It is an extremely difficult matter to measure relative improvement in terms of time or amount of work done, because as one approaches his limit each unit of effort will produce a smaller and smaller gain in time saved or work accomplished.

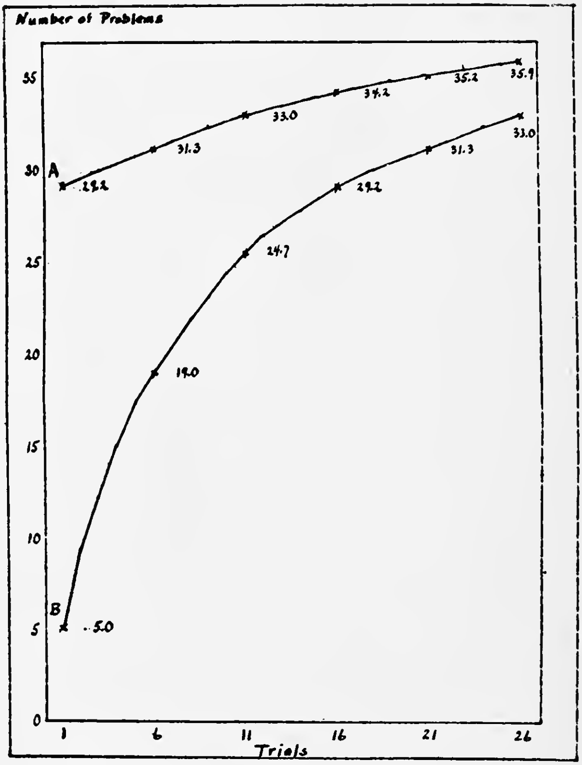


PLATE XIV.—Showing learning curves of two individuals who are identical in all respects save in the amount of training in the arithmetical combinations.

The Effect of Differences in Hereditary Endowment.—How do differences in sheer hereditary endowment affect learning curves? Plate XV illustrates this point. The individual with the best endowment will show the greatest improvement, the person with the least endowment will show the least improvement. Curves B, C, and D represent the learning curves of three persons; curve

B being the curve of the best endowed, curve C being of a poorer endowed person, and curve D being of the poorest endowed person of the three. *The better the original nature of the individual the greater will be the improvement resulting from practice.* These three individuals with equal training and varying degrees of hereditary endowment would not even do equally well, of course, on the first trial, because the better endowed person would do better than the others right from the start.

One warning should be given here. The degree of efficiency of the original nature of the individual must be considered as it applies to the particular task being tested. For example, a great musician (having superior original nature along musical lines) may not necessarily have superior endowment in mirror-drawing. The musician's curve in mirror-drawing will show great improvement or not; depending not upon endowment in general, but upon the endowment which he has that pertains to mirror-drawing.

The Effect of Differences in Training and Heredity Combined.—Now let us consider, third, some combinations of these two factors. We may have four individuals: (1) A having good heredity and previous training, (2) B having good heredity but no previous training, (3) E having poor heredity and previous training, and (4) D having poor heredity and no previous training. (Poor heredity is to be understood as endowment having to do with the trait under discussion; training to be considered in terms of so many units of time devoted to learning specific material.) Then their learning curves would take more or less the forms illustrated in Plate XVI. A and E can be thought of as having had 15 units of instruction, and B and D as having had none. As B is superior to D by hereditary endowment he will do better than the latter at the start and will rapidly leave him behind. (See Plate XV, where this point is alone considered.) The more training they receive the more different will they become as far as this trait is considered, because of the difference in their ability. In the same way A and E, who have had some previous training, become more and more unlike as they continue their training. These curves illustrate, then, the principle that continued tra'ning makes individuals of different hereditary endowment more and more unlike. We shall return to this point a little later.

The curves of A and B are symmetrical, A's curve actually being the same as B's from the latter's 16th trial on to what would be his 41st trial. The curves of E and D are also symmetrical in the same way. Because of their previous training A and E will maintain their superiority over B and D, respectively. This superiority seemingly grows smaller and smaller with practice. It actually does if measured in terms of problems

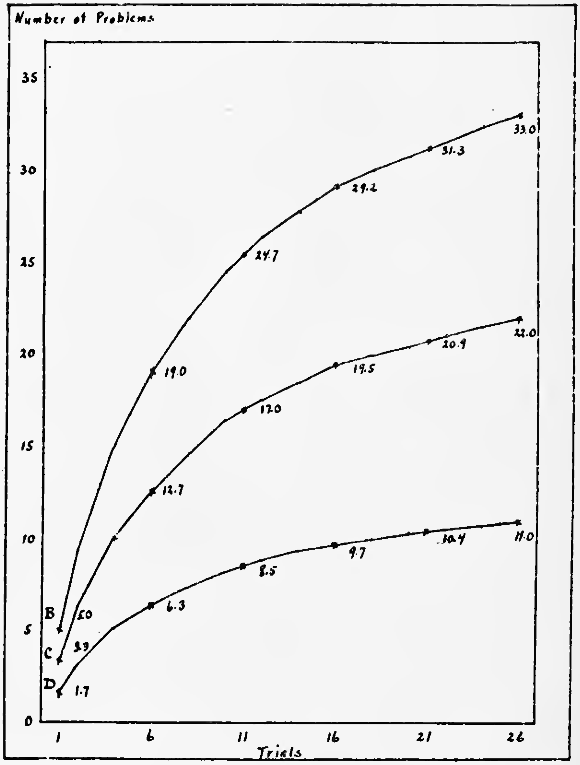


PLATE XV.—Showing learning curves of three individuals with different hereditary endowments.

performed, but it does not if measured in terms of effort, for A always remains ahead of B to the extent of what 15 units of time will produce, and likewise E remains ahead of D to that extent.

The difference between the good heredity of A and B and the poor heredity of E and D is meant to be a considerable difference. Yet it is not exaggerated at all in comparison with the differences

found in almost any class room. The differences between the average of the 4th Grade and the group of retarded children is about equal to that shown here between A and E. In Plate XVII are shown the curves of a child from the 4th Grade and another from the retarded group. The former is not the brightest in that grade (actually rated 11th in a class of 28) and the latter

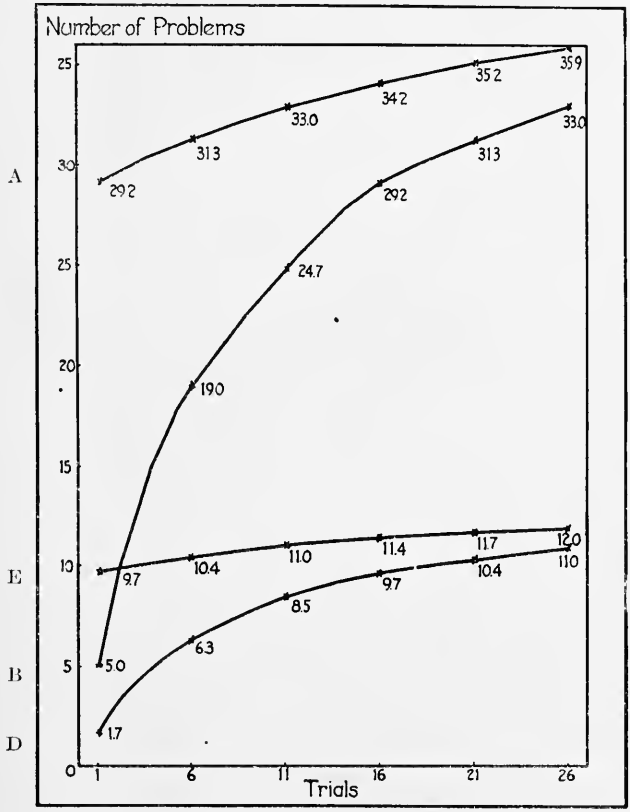


PLATE XVI.—Showing learning curves of four individuals: A with good heredity and previous training; B with good heredity but no training; E with poor heredity and previous training; and D with poor heredity and no training.

is not the dullest among these unfortunate children. In fairness to the records it should be stated that undoubtedly the 4th Grade child practiced on these combinations outside of school. But the dull child had also this opportunity. The curves do epresent cons equently the learning that followed equul stimula-

tions in the school. One child could respond in an adequate manner and did so and the other child could not and so did not. Some students can learn mathematics so that they eventually master calculus and its applications to engineering, while others never get beyond the fundamentals. Some students master the

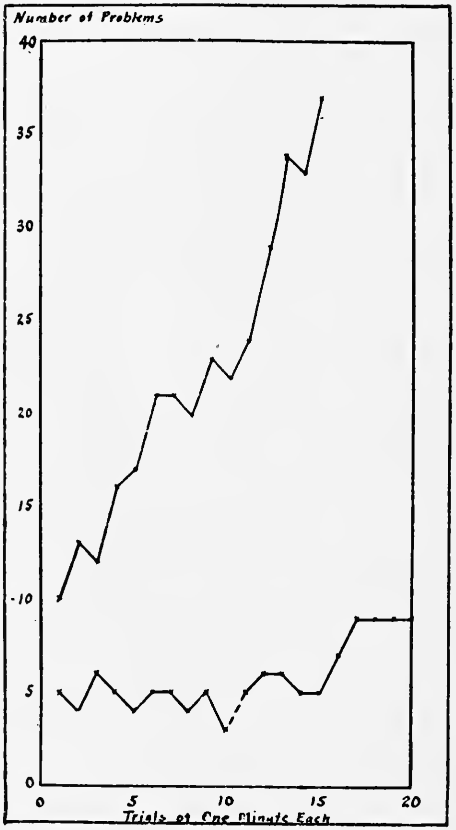


Plate XVII.—Showing learning curves in solving addition combinations (B-Test) for a bright 4th Grade child and a mentally defective child of the same age. (In the case of the latter between trials 10 and 11 there intervened 170 minutes of drill extending over 25 days on addition combinations.)

principles of art and design and become skilled in dressmaking, millinery, architecture, painting, etc., while others are oblivious to the most atrocious combinations of color or form in their clothes, their home surroundings, etc. The gifted child learns

rapidly and improves tremendously; the child who is lacking learns slowly and learns very little.

Individual Differences in Solving Simple Arithmetical Combinations

Let us now more or less review what has been discussed in this lesson but consider the matter in terms of the data studied in Lesson 22.

These data are plotted in Plate XVIII. The curves do not bring out the points so clearly as do the theoretically constructed curves of Plates XIV, XV, and XVI. Nevertheless they bear witness to all of those points.

1. *The greater the amount of practice the higher the curves start.* This point needs no further discussion.

2. *The greater the amount of practice the less rapid the gain.* This point is true but it does not always appear, due to the presence of conflicting factors. Although none of these groups had had any previous training with the particular tests under discussion, yet we naturally would expect the adults to have had more practice and so to show less improvement than the 4th Grade children. The real cause, however, as to why the curves do not clearly illustrate the point made at the commencement of this paragraph is due to the differences in the groups in terms of heredity. Not only are the adults superior to the 4th Grade children because they have a mature development of their hereditary nature, but also without question a class of college men and women are superior to a class of 4th Grade children. That is, the 4th Grade class will not average as high an endowment when they become adults as do the college students. This class of forty-three college students is probably made up of the superior students from forty-three 4th Grade classes. The great differences in heredity cover up then the effect of much practice versus little practice.

3. *The greater the hereditary endowment the greater the improvement from training.* This point is clear from the curves and from what has just been stated.

4. *The greater the training the more a group of individuals become unlike.* At the commencement of the training recorded here the three groups could perform as follows:

Number of problems solved per minute by college students......	59
Number of problems solved per minute by 4th Grade children......	19
Number of problems solved per minute by defective children......	4
Average	27.3
A. D.	21.1

and at the end of ten practice periods they performed as follows:

Number of problems solved per minute by college students......	76
Number of problems solved per minute by 4th Grade children......	30
Number of problems solved per minute by defective children......	7
Average	37.7
A. D.	25.6

As the A. D. has increased we know the groups are less alike than before. This fact is shown also in this way.

College students are superior to 4th Grade Children at start by 40 problems.

College students are superior to 4th Grade Children at end by 46 problems.

Also—

College students are superior to Defective Children at start by 55 problems.

College students are superior to Defective Children at end by 69 problems.

And—

4th Grade Children are superior to Defective Children at start by 15 problems.

4th Grade Children are superior to Defective children at end by 23 problems.

This fourth fact, that training causes a group to "fly apart," to become more and more unlike, due to the inherent differences in the hereditary equipment of the members of the group, affects our school work most profoundly. It makes clear that no grade can be taught as a class without some members very shortly doing such good work as to tempt the authorities to promote them into the next grade and some other children doing such poor work as to lead to their being put back into the grade below or to force the teacher to give them individual instruction. No mechanical administrative scheme for holding a class together will ever work satisfactorily because the members of that class cannot advance

at the same rate. The solution to this difficulty has not been evolved, but if it ever is, in the writer's opinion, it will include a very flexible scheme of promotion by subject-matter, coupled with extensive provision for individual coaching of children that

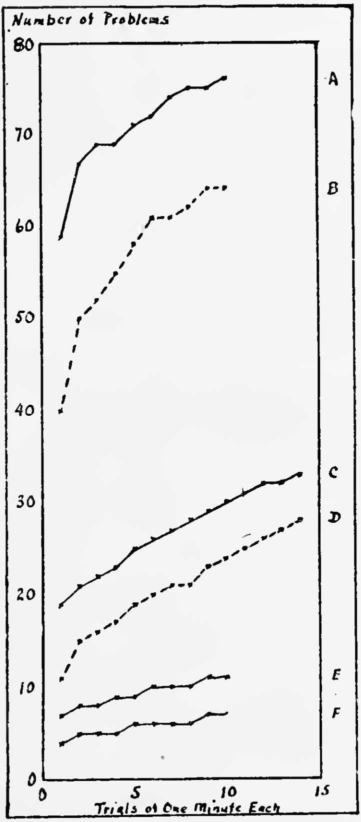


Plate XVIII.—Showing learning curves in solving simple arithmetical combinations: from adults, Curve A (B-Test) and Curve B (BX-Test) from 4th Grade children, Curve C (B-Test) and Curve D (BX-Test); and from defective children, Curves E and F (B-Test)—Curve F prior to and Curve E after 170 minutes of special drill on addition combinations.)

are markedly behind and markedly ahead of their class. This point will be taken up again later. But right now it should be realized that the main point of the whole problem is that children cannot progress in their learning at the same rate—that some go fast, some go slow, and some advance at average speed.

LESSON 24

THE GENERAL LAW AS TO HOW INDIVIDUALS DIFFER

We know that people are different almost before we realize that there are people. We distinguish between tall people and short people, fat people and thin people, clever people and silly people, and most of us would agree fairly well in our classifications. But how do we draw these distinctions? Do we have hard and fast lines, enclosed between which one class is set off from another? Should we say that all men between 0 inches and 62 inches in height, for instance, are short, and those between 62 inches and 84 inches are tall? That any one weighing under 125 pounds is thin or more than 125 pounds is fat? And even if we decide to be so definite in these cases (though certainly our standard is artificial) where shall we draw the line in the case of mental attainments? Are we all talented or stupid, for example? Or are most of us merely average people without special qualifying adjectives, and the rest of us simply either better or worse than the average? That is, instead of having separate little groups of idiots, normal folks, and geniuses, the members of each class keeping carefully to themselves, do we perhaps have but one class of individuals, all typified by the average, yet all varying from the average in greater or less degree?

We are about to perform an experiment in throwing dice. This is as purely a chance performance as we can get. Let us see if the throws are distinctly different or whether they follow one general law. For example, can we divide the throws into two groups—high and low, or must we think in terms of one group with variations from its average? In any case the results may apply to our biological problem as given above.

The Experiment

Problem.—In throwing dice are the totals distinctly different or do they approach a general type?

Apparatus.—Coördinate paper; 3 dice.

Procedure.—*Part* 1. Lay off on your coördinate paper a base line, and number the squares from 0 to 18, as is done in Plate XIX. Lay off a vertical axis and number the squares from 0 to 35 (Plate XIX only shows to 8). Now commence and throw your three dice. Count up the total of the three dice and record that total on your coördinate paper in its proper place. (The writer threw first a 4, 3, and 1, making a total of 8.) A "1" (first throw) is placed in the square on the coördinate paper immediately above the 8 on the scale. A total of 11 was next thrown by the writer and it is indicated by the "2" in the plate. A total of 14 was thrown third, etc. Twenty-five throws are indicated in this Plate, the twenty-fifth throw being a total of 7. Plate XIX shows then that the writer threw

one 6	two 12's
one 7	one 13
three 8's	two 14's
three 9's	one 15
six 10's	one 16, and
three 11's	one 17

Thus 25 throws are distributed or indicated in the plate.

Record in this way 100 throws. Show your completed diagram to the instructor before proceeding further.

Such a diagram is called a *surface of distribution* as it shows just how all the throws were distributed among the possible totals.

Part 2. Now determine how many different totals can be

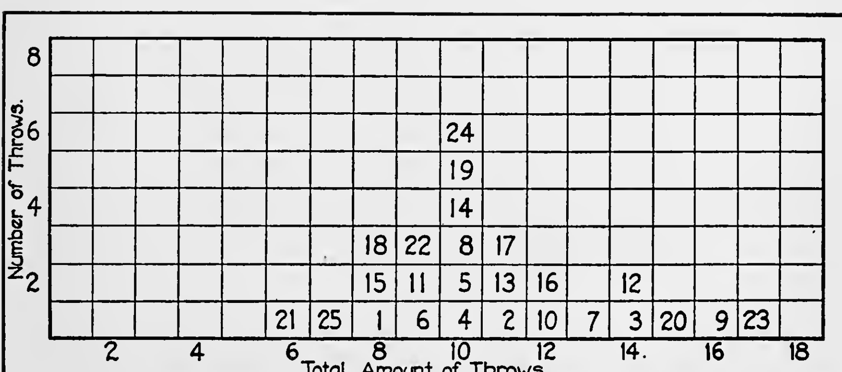


PLATE XIX.—Illustrating by means of a "surface of distribution" twenty-five throws of three dice.

obtained by throwing three dice. (In Plate XIX are indicated 12 different totals, i. e., from a total of 6 to a total of 17, inclusive.) Present your answer to your instructor before proceeding further.

Part 3. Now figure out (a) all the possible different combinations[1] it is possible to obtain by throwing three dice. (Assume one of the three dice is red, another is blue, and the third is white. Then one on the red die, two on the blue, and three on the white is a different combination from one on the red, two on the white, and three on the blue, or from two on the red, one on the blue, and three on the white. The question is, how many different combinations are there?)

Also figure out (b) how many of each total you will obtain when every possible combination is considered.

Part 4. Suppose instead of getting the 100 throws you did get, you had thrown the dice as many times as there are different combinations and in throwing the dice that number of times had got each and all of these different combinations. Plot a surface of distribution to illustrate just this.

Part 5. What relation exists between the surface of distribution you actually obtained by throwing the dice 100 times and the surface of distribution obtained in the preceding paragraph?

What relation do you think there exists between the findings in this experiment of throwing dice and the general problem of how individuals differ? Can throws be divided into two or more groups; can individuals?

Hand in your report at the next class-hour.

[1] Mathematically speaking what is wanted here is permutations, not combinations. That is, in forming combinations we are only concerned with the number of things each selection contains, whereas in forming permutations, we have also to consider the order of the things which make up each arrangement; for instance, if from six numbers, 1, 2, 3, 4, 5, 6, we make a selection of three, such as 123, this single combination admits of being arranged in the following ways:—123, 132, 213, 231, 312, and 321, and so gives rise to six different permutations.

LESSON 25

THE GENERAL LAW AS TO HOW INDIVIDUALS DIFFER (continued)

The Normal Surface of Distribution

If one should take three dice and throw them 216 times, each time counting up the total score and plotting this score, one might obtain a surface of distribution somewhat like the three surfaces shown in Plate XX. The first and third were actually so obtained, the middle one is the perfect surface which theoretically chance should give.

One may figure out this theoretically perfect surface in this way. Count up all the throws that are possible and record how many times each total appears. You may have

1 and 1 and 1, a total of 3
1 and 1 and 2, a total of 4
1 and 1 and 3, a total of 5
1 and 1 and 4, a total of 6
1 and 1 and 5, a total of 7
1 and 1 and 6, a total of 8
1 and 2 and 1, a total of 4
1 and 2 and 2, a total of 5
etc.

When you have so obtained all the 216 totals you will find that you have

1 total of 3	27 total of 11
3 totals of 4	25 total of 12
6 totals of 5	21 total of 13
10 totals of 6	15 total of 14
15 totals of 7	10 total of 15
21 totals of 8	6 total of 16
25 totals of 9	3 total of 17
27 totals of 10	1 total of 18

When these data are plotted you have the ideal surface of distribution in Plate XX. All this means that when you throw three dice you are just as likely to get any one combination as

any other. But you are more likely to get a total of 10 or 11 than 3 or 18. You can express this likelihood by the expression 27 to 1, for there are 27 combinations that will give a total of 10 or 11, whereas there is only one combination that will give 3 or 18. Our normal curve of distribution represents then that surface most likely to be obtained by 216 throws. Actually we seldom get exactly that ideal surface, but we do get surfaces that approximate it in general appearance.

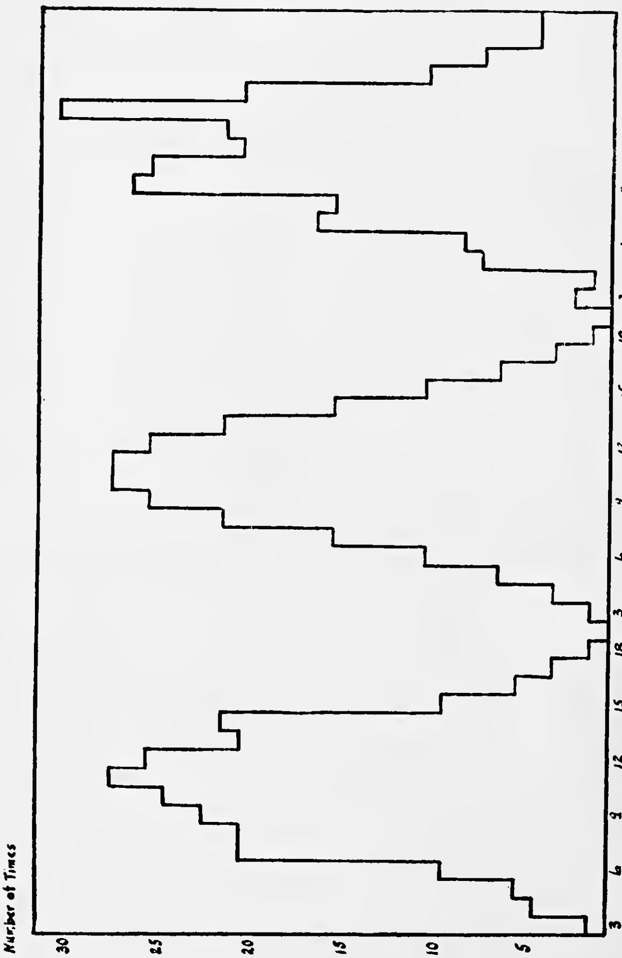


Plate XX.—Three surfaces of distribution obtained from throwing three dice 216 times. The first and third surfaces were obtained from 216 actual throws. The second is based on what theoretically should be obtained from that number of throws.

One may think of this matter of throwing three dice as being conditioned on three independent factors, each one of which may vary independently in six different ways. When the three independent factors with their six possible variations are considered as a whole, we realize that there are 216 independent combinations possible. But the 216 independent combinations do not give 216 different final scores. They give but 16 different scores (from 3 to 18). Nor do the 216 combinations give an equal number of each of the 16 different scores. They give varying numbers of the 16 different scores—only one 3, three 4's, six 5's, etc., as in the table above.

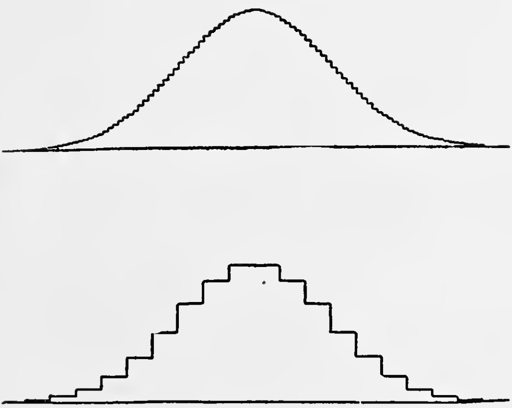


PLATE XXI.—The normal curve or surface of distribution. The two curves differ only in that a coarse unit of measurement was employed in the second case whereas a fine unit was employed in the first case;—i. e., inches vs. eighths of an inch. (From E. L. Thorndike, *Educational Psychology*, Vol. III, p. 334.)

Now in a similar way we may think of the characters of different individuals as the final totals resulting from the interaction of many independent factors, each of which may vary independently in many ways. Instead of there being but three factors with six variations each, which combined give us our human individualities, there are undoubtedly many more than three factors and these factors have many more than six variations. Nevertheless the final outcome is very similar to what we obtain by throwing dice. We find that most of the individuals, just like most of the throws, give us individualities that resemble each other very much, just as the throws of 8, 9, 10, 11, 12, and

13 are very much alike. We find also that occasionally we get very striking personalities, just as very occasionally we get throws of 3 or 4 or 17 or 18. They are striking because they differ so from what we ordinarily have.

In Plate XXI are given two different methods of drawing the typical surface of distribution. In the lower of these two surfaces there was used a very coarse unit of measurement, e. g., inches in measuring height, and in the upper surface there was used a very much finer unit of measurement, e. g., eighths of an inch. We can imagine a surface drawn on the basis of a still finer unit of measurement. In this case the jogs in the line would be very, very small, so that for all practical purposes the line would be a smooth curve and not a jagged line. Such a curve is called the *normal curve of distribution.* In terms of geometry the normal curve of distribution is the limit approached by most surfaces of distribution which are obtained in biological studies.

The Distribution of Individual Differences

An Ideal Distribution.— When we come to study human beings we find that they fit into our normal surface wonderfully well. In fact, the conception has been derived from our study of individual differences. In Plate XXII is shown a normal curve of distribution picturing the different types of individuals according to general intelligence. In the middle are the great bulk (50%) of human beings—average human beings. As we proceed to the left, we have individuals slightly below the average; "dull" persons; morons with intelligence approximately equal to children from 8.0 to 10.0 years;[1] and then imbeciles with intelligence of from 2.0 to 8.0 years; and idiots with intelligence of from 0.0 to 2.0 years. The remaining 0.001% of the inferior population can possibly be thought of as being too inferior to live and so constitute a fraction of those who are born dead. In the same way we may divide up our superior individuals proceeding from the middle group out toward the right. Apparently we have no terms to cover these superior individuals so that the

[1] There is a great deal of controversy today as to what should be the proper mental age limit of morons. Some writers place it as high as 12 years. Experienced based upon testing men in the army makes 10 years a satisfactory figure.

expressions used here have no standard meaning. To the right of the group entitled "National Leaders," comprising 29,000 in a population of 100,000,000, are still 1,000 individuals not to be overlooked. They comprise our most valuable men, our geniuses, etc.

Cattell,[1] in his study of the thousand most eminent men of history, studied a group even more eminent than these since his thousand was not taken from a population of 100,000,000

[1] J. McK. Cattell, A Statistical Study of Eminent Men, *Popular Science Monthly*, Feb., 1903.

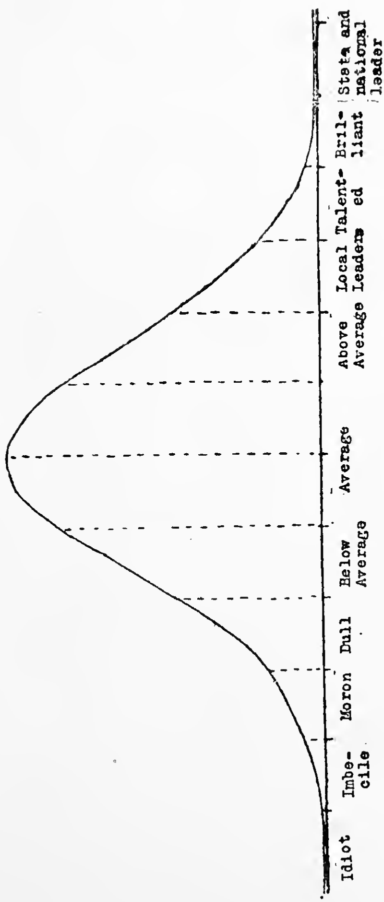


Plate XXII.—A normal surface of distribution divided up into twelve groups showing eleven degrees of general intelligence (the middle two groups are together considered as typical of average intelligence).

but from the population of the known civilized world. They would be located on this diagram several groups to the right of the group here entitled "National Leaders." According to Cattell the ten most eminent men of all history are the following in the order of their prominence:—Napoleon, Shakespeare, Mohammed, Voltaire, Bacon, Aristotle, Goethe, Julius Cæsar, Luther, and Plato.

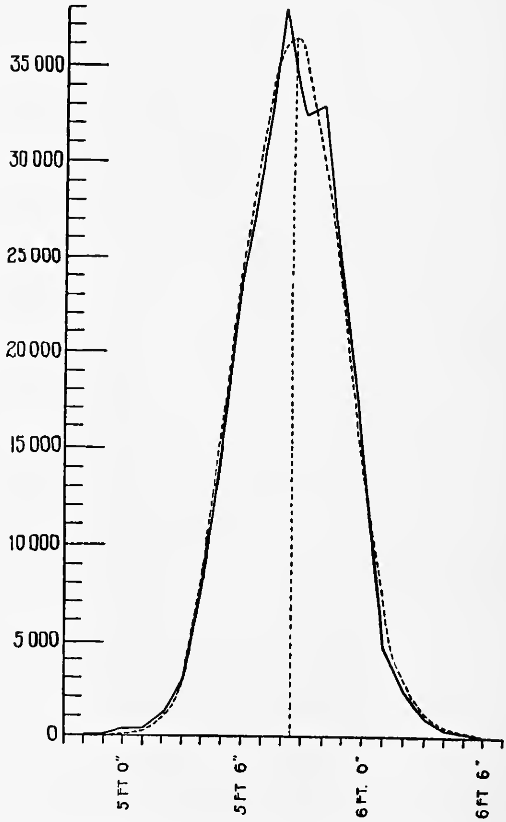


Plate XXIII.—Showing distribution of height of 221,819 men. (Quoted from note of E. G. Boring in *Science*, Nov. 12, 1920, p. 465f).

Actual Distributions of Individual Differences

Plates XXIII and XXIV present distributions of physical height and general intelligence. In both these cases the actual distribution very closely approximates to the smooth, normal

curve. They emphasize again that men vary; also that they cluster around one central tendency or type.

In Lesson 21 our attention was called to the fact that the averages of the eight grades of a school may be equal or superior to the norms for those grades, and yet many children in each grade may be in a very bad way educationally. The specific case was mentioned of testing a school with the Kansas Silent Reading Test and the individual scores for all the children were presented in Table V. These scores are again given in Plate XXV, where they are displayed as surfaces of distribution. Because of the

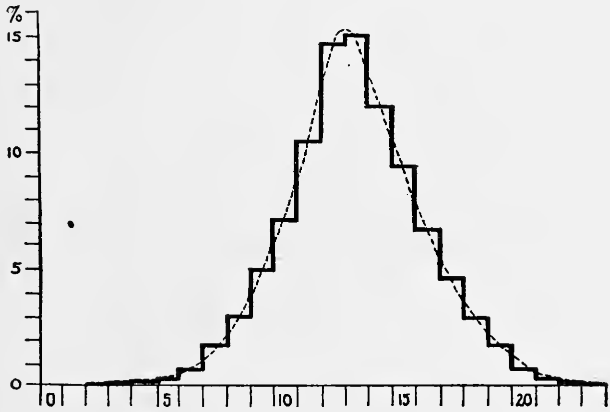


PLATE XXIV.—Showing distribution of 93,965 white men in the army draft in terms of intelligence test scores. (From Memoirs, National Academy of Science, Vol. XV, 1921, p. 653.)

small number of children in any class these surfaces only remotely approximate the form of the surface of distribution which would be obtained if there had been 100 or 200 children in each grade. When the scores from all the children in Grades IV to VIII are combined, as they are in the lower part of Plate XXV, a surface of distribution much more similar to the typical form is obtained. If the scores from the children in Grades I to III had been included the surface of distribution would be still more similar to the usually obtained form. The form obtained here is typical of the form which results from a study of individual differences in nearly all traits, both mental and physical.

During the war a psychological "general intelligence" test was given to hundreds of thousands of the enlisted men and to many

of the officers. Distribution of the scores obtained from enlisted men is shown in Plate XXIV; also again in Plate XXVI, together with the distribution of officers' scores. The two distributions

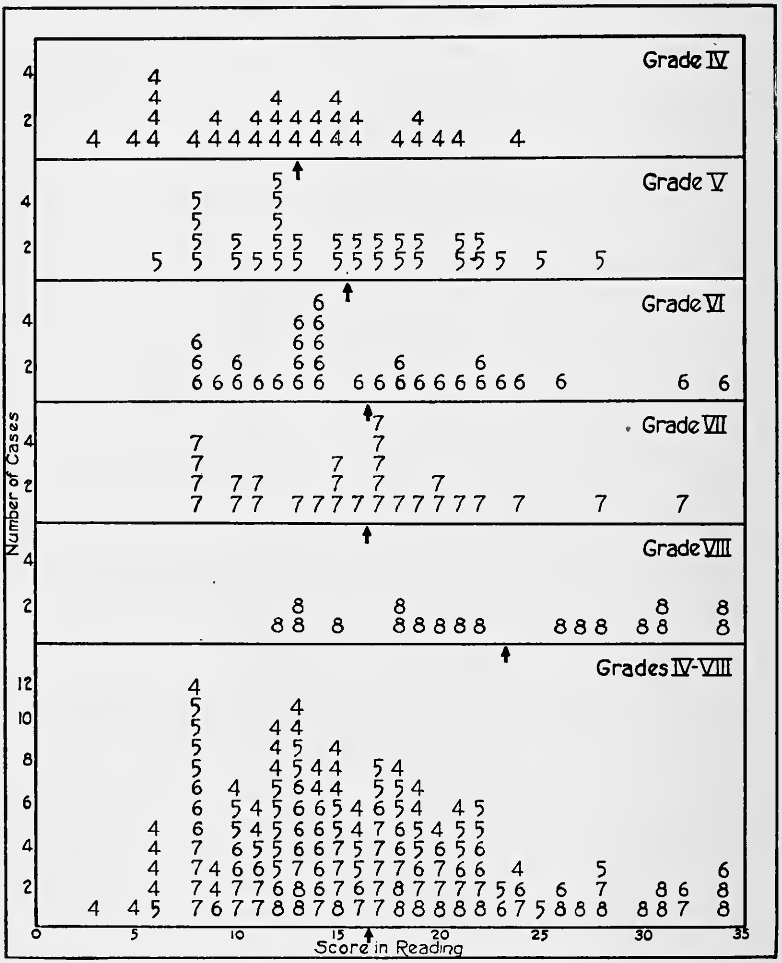


Plate XXV.—Showing the Distribution of Children in Grades IV to VIII, based on the Kansas Silent Reading Test. (See Table V for individual scores.) (Averages of each grade indicated by the arrows.)

are based on data which are not quite comparable and so can not be directly contrasted. Plate XXVI shows that the officers

as a class were superior to the enlisted men in intelligence. This fact may be expressed also as follows:

2.4% of the enlisted men were superior to 75% of the officers
6.4% of the enlisted men were superior to 50% of the officers
12.2% of the enlisted men were superior to 25% of the officers

Intelligence is not the only qualification needed by officers. Some of those with low intelligence scores were superior in leadership and experience. In the same way some of the enlisted men who were very superior in intelligence had very poor phy-

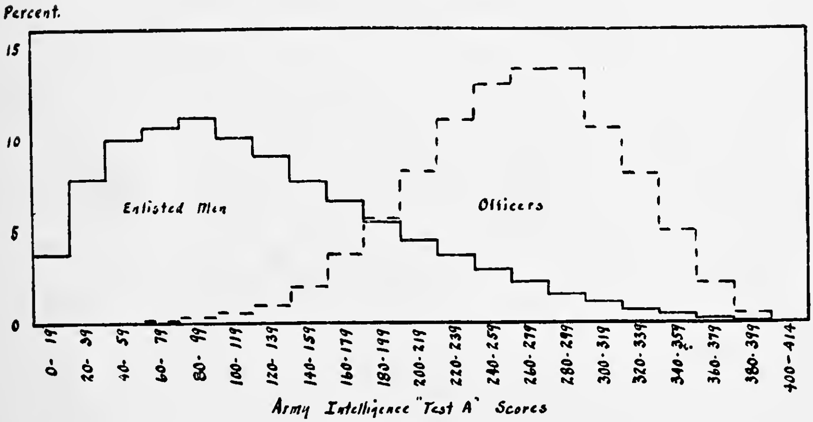


Plate XXVI.—Showing the distribution of scores obtained by enlisted men and officers in psychological intelligence test (Test A). Based on scores of 128,-747 "literate" men and 8,096 white officers. Undoubtedly many enlisted men too illiterate to take the test were included here.

sique and appearance or were lacking in education or leadership, etc. From the standpoint of the psychologists and personnel officers the problem of selection of men for officers' training camps was to find the superior enlisted men—superior both in intelligence and other necessary qualifications.

The sharp drop at the extreme left of the enlisted men's distribution curve proves conclusively that many enlisted men were not measured here who belonged to the group of enlisted men. This was true. Twenty-five per cent. of men were eliminated by the draft boards as below standard physically, mentally or morally. And the worst illiterates were not given the test.

Illiterates and those making a poor score in this test were given a test not involving reading.

Fundamental Causes of Individual Differences

Individual differences are to be thought of as the resultant of many more or less independent factors, each of which vary considerably. These factors may be grouped under the three headings—environment, heredity and training. In the case of heredity, we may look upon a human being as made up of many factors handed down to him from his parents through the two germ cells. These factors are more or less independent. According to the combination which results from all these factors we have any particular human being. As illustrated by the experiment in throwing dice, although there may be many combinations of factors with their individual variations there results (1) a much smaller number of distinct individualities and (2) the great majority of such individualities are much alike with only relatively few cases of marked variation from the average.

At the present time science has ascertained in only a few cases what the factors are which affect human beings so as to make them different. And even there this has been done only to a limited degree. One example may be mentioned simply to make this matter clearer. In the throat or neck are some small glands known as the *thyroid* glands. They secrete into the blood a substance which is "characterized by containing a large amount of iodin (9.3% of the dry weight)." This chemical, apparently, exercises in the tissues "a regulating action of an important or indeed essential character." Removal or atrophy of the thyroids results in a condition of chronic malnutrition; "in the young it is responsible for arrested growth and deficient development designated as cretinism, and in the adult the same cause gives rise to the peculiar disease of myxedema, characterized by distressing mental deterioration, an edematous (dropsy of the subcutaneous cellular tissue) condition of the skin, loss of hair, etc." On the other hand, enlargement of the thyroid glands "forms an essential factor of the disease exophthalmic goitre." "The salient feature of exophthalmic goitre is a lowered threshold to all stimuli." "The organism responds at such times to the

prick of a pin, a hint of danger, or the slightest infection, by a transformation of energy many times greater than would follow the same stimulation in the normal organism." Patients suffering from cretinism are now fed this iodin chemical, whereas patients suffering from exophthalmic goitre are operated on so as

TABLE VII.—SHOWING THE PERCENTAGE OF 4TH AND 8TH GRADE CHILDREN WHO (*a*) ATTEMPTED AND (*b*) SOLVED FROM 0 TO 20 PROBLEMS

Per cent. of pupils who *attempted* to do a given number of problems		Per cent. of pupils who *solved correctly* a given number of problems	
4th Grade	8th Grade	4th Grade	8th Grade
20 Probs.— 0%	20 Probs.— 5%	20 Probs.— 0%	20 Probs.— 2%
19 Probs.— 0	19 Probs.— 2	19 Probs.— 0	19 Probs.— 1
18 Probs.— 0	18 Probs.— 2	18 Probs.— 0	18 Probs.— 1
17 Probs.— 0	17 Probs.— 3	17 Probs.— 0	17 Probs.— 1
16 Probs.— 1	16 Probs.— 4	16 Probs.— 0	16 Probs.— 2
15 Probs.— 1	15 Probs.— 6	15 Probs.— 0	15 Probs.— 2
14 Probs.— 1	14 Probs.— 7	14 Probs.— 0	14 Probs.— 3
13 Probs.— 1	13 Probs.— 8	13 Probs.— 1	13 Probs.— 4
12 Probs.— 1	12 Probs.— 9	12 Probs.— 1	12 Probs.— 5
11 Probs.— 2	11 Probs.—11	11 Probs.— 1	11 Probs.— 7
10 Probs.— 4	10 Probs.—11	10 Probs.— 1	10 Probs.— 8
9 Probs.— 5	9 Probs.—10	9 Probs.— 2	9 Probs.— 8
8 Probs.—12	8 Probs.—10	8 Probs.— 3	8 Probs.—10
7 Probs.—14	7 Probs.— 6	7 Probs.— 6	7 Probs.—10
6 Probs.—21	6 Probs.— 4	6 Probs.— 9	6 Probs.— 0
5 Probs.—14	5 Probs.— 1	5 Probs.—12	5 Probs.— 9
4 Probs.—13	4 Probs.— 1	4 Probs.—14	4 Probs.— 7
3 Probs.— 6	3 Probs.— 0	3 Probs.—14	3 Probs.— 6
2 Probs.— 3	2 Probs.— 0	2 Probs.—13	2 Probs.— 3
1 Probs.— 1	1 Probs.— 0	1 Probs.—13	1 Probs.— 1
0 Probs.— 0	0 Probs.— 0	0 Probs.—10	0 Probs.— 1
Aver. 6.44	11.65	3.81	8.41

to reduce the amount of this chemical given off by the thyroid glands. We see here a single factor in the entire organism—the production of an iodine chemical—which when only slightly produced results in cretinism (deficient physical and mental

development), when normally produced results in normal behavior, and when excessively produced results in goitre accompanied by a chronic state of great excitability.[1]

The Overlapping of Distributions of Ability in Different School Grades

The scores of children in the Kansas Silent Reading Test for the various school grades overlap very greatly (see Plate XXV). Because such overlapping is one of the most important conceptions in educational theory today, it will repay us to consider

[1] Quotations are from W. H. Howell, *Physiology*, 1907, pp. 794–797 and G. W. Crile, *Man—An Adaptive Mechanism*, 1916, pp. 140–143 and 192–197.

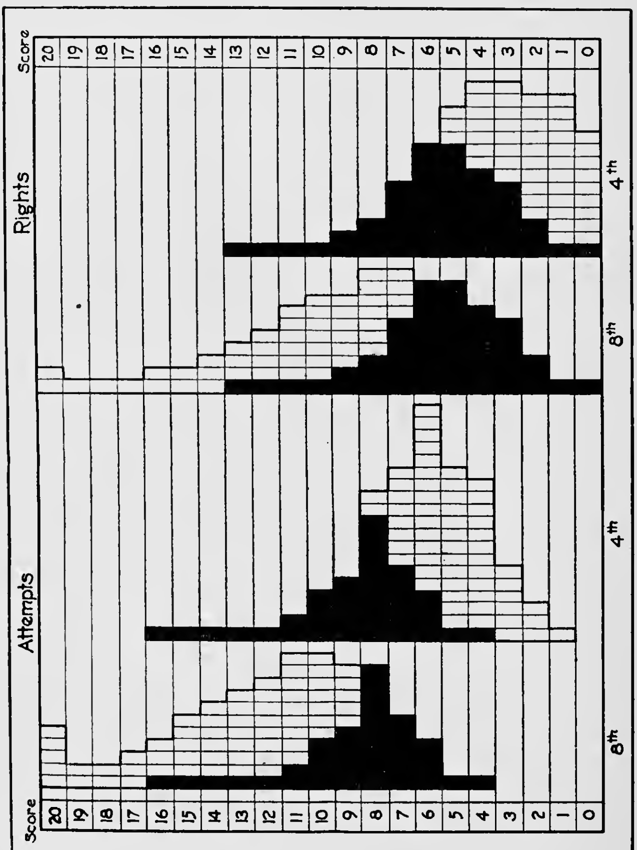


Plate XXVII.—Showing the percentage of 4th and 8th Grade children who (*a*) attempted and (*b*) got right from 0 to 20 problems in eight minutes. (Each small oblong represents one child in a class of one hundred. The black oblongs represent children in the 4th Grade who could be interchanged with corresponding children in the 8th Grade without affecting the averages or A. D.'s of either grade. From S. A. Courtis, Educational Diagnosis, *Second Indiana Educational Conference*, 1915, *p.* 154.

two other examples of it here. The Courtis Arithmetic Tests are employed to find out how rapidly and accurately pupils can do certain of the fundamental processes. For example, one of the problems in the column addition test is made up of the following numbers:—837, 882, 959, 603, 118, 781, 756, 222, 525.

Courtis[1] measures the *speed* of work by recording the number of problems "attempted" and the *accuracy* of the work by recording the number of problems which were "right" or correct. The four columns in Table VII show what per cent. of the two grades "attempted," or got "right," any specific number of problems ranging from 20 to 0. For example, the table shows that 0% of the 4th Grade attempted 20 problems while 5% of the 8th Grade attempted that number, and it shows that naturally 0% of the 4th Grade got 20 problems right, while 2% of the 8th Grade did solve that number correctly. It shows further that 1% of the 4th Grade attempted 12 problems as against 9% of the 8th Grade, and that 1% of the 4th Grade got 12 problems right, as against 5% in the 8th Grade. If we want to know just how many children attempted or solved correctly 12 or more problems in the two grades we must add up all the percentages in the table for 12 problems and better. This gives us the following: 5% of the 4th Grade attempted 12 or more problems as against 46% of the 8th Grade and 2% of the 4th Grade got right 12 or more problems as against 21% of the 8th Grade. All of this is shown diagrammatically in Plate XXVII.

The averages of the 4th and 8th Grades are given at the bottom of the table. The 8th Grade has done just about twice as well as the 4th Grade on the basis of these figures. In terms of such figures one would expect that *all* 8th Grade children would be superior to *all* 4th Grade children for the former averages 8.4 problems correct to 3.8 problems for the latter. But a study of the table and particularly the plate shows that this is false. Fifty-one of the children from the 8th Grade could be put in the 4th Grade and a corresponding number from the 4th Grade be put in the 8th Grade and the averages of the two grades for accuracy would not be affected at all. When we give our 8th Grade children a diploma, graduating them into the High School, we feel that the diploma means that they are up to 8th Grade

[1] S. A. Courtis, Educational Diagnosis, *Second Indiana Educational Conference,* 1915, p. 154.

standards and far superior to 7th, or 6th, or 5th, or certainly 4th Grade standards. But apparently many in the class are not. For here in this perfectly typical illustration based on about 11,000 children, 38 in every hundred 8th Grade children are no different from 38 other children in the 4th Grade as regards their speed of adding and 51 in every hundred 8th Grade children are no different from 51 other 4th Grade children as regards their ability to add correctly columns of figures.

The A. D.'s for the data in Table VII concerning the ability of children in the 4th and 8th Grades to add columns of figures are:—

Average number of problems attempted in 4th Grade.	6.44	A.D. 1.94
Average number of problems attempted in 8th Grade.	11.65	A.D. 2.69
Average number of problems correctly solved in 4th Grade......................................	3.81	A.D. 2.19
Average number of problems correctly solved in 8th Grade......................................	8.41	A.D. 3.09

As pointed out in Lesson 21 the size of these A. D.'s immediately warns us against supposing that all the children are equal to the average for their grade. They also confirm again the point made in Lesson 23 that the greater the training the more the individuals are different. Inspection of the surfaces of distribution in Plate XXVII. as well as the size of these A. D.'s shows that the members of the 8th Grade differ more among themselves than do the members of the 4th Grade. This fact would be all the more clearly shown if the children who have dropped out of school between the 4th and 8th Grades, were present in this 8th Grade. For most of them would appear at the lower end of the surface of distribution.

A survey was made of English composition at Purdue University in September 1919, the freshmen being required to write a short composition. Results showed that 10 %, excluding foreign students, "have composition ability on the same level as the sixth grade in Detroit, Michigan." Work typical of this poorest 10% was as follows:—

"One night last winter. I got into my mother's cubord, and got a whole mince pie and ate it, just before going to bed. And of all the bad dreams I had the worst.

"I drempt I was taken to China and roasted alive. Next the India tans tortured me, then I was taken to Africa and left in

the jungles and again I was in a ward with the small pox and when I was about to die I awoke with a sick headache."

"There were 111 compositions of about this quality . . . This may be taken as indicating that 10% of the entering class, either on account of innate mental deficiency or inadequate training, have not mastered the elementary mechanics, the simple conventional technique of expressing their thoughts in written form. These students are evidently not prepared to do high school work in English, to say nothing of attempting freshman work in college . . .. The assumption that all freshmen are prepared to do the same type of English work, and the fairly common practice of grouping, instructing, and grading on this basis, seems to be without any pedagogical justification."[1]

This matter of how students differ among themselves is a very important problem affecting our whole educational system in a very profound way. When we realize that 51% of 8th Grade children add columns of figures no more accurately than a corresponding percentage of 4th Grade children and that 10% of college freshmen write compositions no better than average sixth grade children we must realize that something is wrong with our school system. All of our methods of study, all of our methods for supervision, and all of our administration schemes should be subjected to careful scrutiny in order to see if any of them are the cause for such astounding comparisons. Possibly, radical changes might produce a more uniform proficiency in the grades. Possibly the graded system itself is at fault. Possibly the differences discussed here are inherent in children themselves, so that very little or nothing can be done to rectify the matter. If that is the case, then, changes possibly should be made so that all diplomas might have a more definite meaning than they now appear to possess.

[1] G. C. Brandenburg, The Quality of Freshman Composition, *School and Society*, Dec. 17, 1921.

LESSON 26

HOW SHOULD STUDENTS BE GRADED?

One of the most perplexing problems in education today is that of grading students. Until very recently the subject was ignored, for it was taken for granted that if a person was capable of teaching his class he was capable of grading the students in that class. Even today, the vast majority of teachers consider it their inalienable right to grade as they please and strenuously resent any interference with their methods. Recent studies made on this subject show, however, that teachers differ very widely in the way they grade their students. In fact, the variation is so great that it is perfectly apparent that all cannot be grading their students fairly. And when "honors" are based on the grades of different instructors the injustice of the present system is clearly apparent. A friend of the writer deliberately restricted his work as far as possible to the three departments of Latin, German, and History in a great university, because he realized that it was easy to make high grades there and he was determined to win Phi Beta Kappa. These three departments granted "A's" to 30% of their students, while many other departments granted "A's" to less than 5% of their students. He made his Phi Beta Kappa key but at the expense of a broad, well-rounded college training. If he had taken courses from many departments he would have stood certainly less than half the chance of getting high grades and probably not more than one-third the chance.

Below are given (See Table VIII) the grades which an instructor awarded a class in history. They are the grades from three examinations, and the final grade for the semester is to be made up from them, each of the three to count one-third of the final grade. (The grades were obtained by the instructor assigning definite values to each question or part of a question, scoring the student in terms of each question, and finally adding up all these separate scores. The grades given here have been modified

somewhat by the writer but they approximate in a general way the grades actually given by this instructor.)

Plot surfaces of distribution for the three sets of grades listed below.

TABLE VIII.—THE GRADES GIVEN BY AN INSTRUCTOR IN THREE EXAMINATIONS. WHAT SHOULD BE THE FINAL GRADE OF EACH STUDENT?

STUDENTS	FIRST EXAM.	SEC. EXAM.	THIRD EXAM.
1	60	100	70
2	55	90	55
3	50	80	80
4	45	95	55
5	45	85	70
6	40	95	50
7	40	80	50
8	35	70	65
9	35	85	45
10	30	75	60
11	30	80	50
12	30	90	75
13	25	95	30
14	25	90	60
15	20	90	55
16	20	85	55
17	20	80	35
18	15	100	50
19	15	65	40
20	10	80	45
21	10	85	35
22	5	85	45
23	5	60	30
24	0	75	25

Answer the following questions:—

1. Who is responsible for the low grades in the first examination and the high grades in the second examination? Do the grades mean that the students loafed before the first examination and studied hard before the second? Or do they mean that the first examination was too hard or too long and the second too easy or too short? Or do they mean that the course of study was poorly organized at the beginning and the teaching was poor at the start and after the poor showing in the first examination the teacher "woke up" and "got busy" and did good teaching?

Who, then, is primarily responsible for the grades in the first

examination ranging from 60 to 0 and in the second examination from 100 to 60?

2. Which grade represents the greater ability, 60 given in the first examination or 80 given in the second? 60 is 20% inferior to 80, of course. But, on the other hand, only one student received 60 in the first examination and none received a higher rating, whereas in the second examination 5 students received 80 and 14 more received higher grades than 80.

3. If we arrange the students in order of merit according to their grades in the examinations, we find that

the best student got 60, 100, and 80, respectively,
the 12th student got 30, 85 and 50, respectively, and
the poorest student got 0, 60 and 25, respectively.

Are 60, 100 and 80 equal then? Or 30, 85 and 50? Or 0, 60 and 25?

4. In grading examination papers should we grade in terms of the "ideal" paper, the best paper, the paper of an average student, the poorest paper or "zero" knowledge? With which one of these standards is the teacher most likely to be familiar? Which one is most likely to fluctuate from year to year?

5. What final grades would you give these 24 students on the basis of the three examinations? Plot the surface of distribution for the grades you assign.

6. Are your final grades fair to the students? To the instructor? To students in other sections of this same history course? To other instructors? To the institution as a whole? Explain.

Hand in your report at the next class-hour.

LESSON 27

METHODS OF GRADING STUDENTS

The matter of grading students in a class is a subject that is intimately connected with the subject of individual differences. It is introduced here as an illustration of how this subject is related in still another way to educational theory and practice.

SYSTEMS OF MARKING STUDENTS

Grading on Percentage Basis with Prescribed Passing Mark.—One of the two most universally used systems of grading students is to give students grades ranging from 0 to 100, with some grade as 50, or 60, or 75, or even 80, as a passing mark.

The theory underlying the granting of percentages is that the student is *graded in terms of absolute proficiency*. If he gets 90 in an examination in arithmetic or spelling, he has done 90% of the examination correctly. The system works fairly well here. But it falls down completely in such subjects as English composition, or history or geography, etc. For who knows what is absolute proficiency in composition work for 5th grade children? How does such a standard differ from that of the 4th grade, or that of the 6th grade? Actually in ordinary practice the grades represent at best only a certain percentage of what the teacher considers the class can do. It is based on two very variable things—the teacher's estimate of what the class can do, and second—the class itself. If the class is better than usual, the teacher's grades stand for better work than usual; if the class is poorer than usual, the teacher's grades represent poorer work than usual. Despite the best efforts of any teacher his grades are not standardized on the basis of a fixed absolute standard but vary with the calibre of his pupils. It is impossible under such conditions to ever expect that a "85" will represent a definite standard of work in a particular course. The 85 will vary from year to year with the same teacher, and it will vary with every two teachers, depending on those teacher's estimates of what a class can do.

(All of these statements have been substantiated in every investigation on this subject and are no longer open to argument.)

The Jury System of Grading.—In some cases grades are awarded by a committee or jury instead of by one instructor. This system eliminates a good deal of the personal bias of a particular instructor and undoubtedly does tend to standardize the grades. It is especially applicable in grading performance in art, architecture, music, and the like. The system is also used in this way. All the instructors of Freshman mathematics, as a committee, draw up the examination questions. Later each instructor grades one question in all the papers of all the sections. Here the examination questions are more carefully considered than is usually the case, and each question is marked for all papers in as nearly the same manner as it is humanly possible to provide. But the jury system does not eliminate marked variations in grading between juries.

Grading on Basis of Five Groups.—The other most universally used system of grading students is to give the students grades in terms of about five letters or numbers, such as A, B, C, D, and F; or E, S, M, I, and F; or again 1, 2, 3, 4, and 5. The A, E, or 1 is given to the best students; the B, S, or 2, to the next best group, etc. The F or 5 is considered as failure. Sometimes the fourth grade, D, I, or 4 is "not passing" and sometimes it is considered as "conditioned" requiring another examination. At still other institutions D is a passing grade but entitles the student to but 80% credit, so that in a 5-hour course the student with a D will receive but 4 hours credit.

It is because of insurmountable difficulties pointed out above in connection with the percentage system of marking that thic system of grading students with five letters has arisen. The whole scheme of grading students on the basis of an absoluts standard of perfection is thrown away, or almost thrown away.[1] The teacher then roughly divides the class into five groups, the excellent students, the good, the fair, the inferior, and the failures. More or less of the old scheme survives in the case of deciding

[1] Of course, in those cases where a teacher marks a student by these five letters but always translates the letter into a numerical figure so that A equals 100 to 95; B, 95 to 85; etc., he is practically following the first scheme and not the second. When the second scheme is used properly there are no numerical values attached to the letters.

just what will constitute a passing standard as distinguished from a failure. The essential thing, however, is the division of the class into five groups in terms of their general ability and performance in the particular class.

Anyone familiar with the laws underlying individual differences immediately realizes that these five groups should not contain an equal number of students;—that the largest number of students should be in the middle group, and that relatively few should be in the two extreme groups, the excellent students and the failures. But the study of how teachers grade students shows clearly that teachers differ enormously as to how they distribute their grades under this scheme. In Table IX is shown the distribution of grades in seven courses in the University of Missouri prior to 1908. It is clear from this table, and it represents conditions in every institution of that time and most institutions today, that a student could quite easily win "honors," or a scholarship, or make Phi Beta Kappa by electing Philosophy, Economics, etc., but would have an extremely small chance of obtaining these honors if he grouped in Chemistry. Yet an "A" counted equally toward these honors whether obtained in Philosophy or Chemistry III. In the same way a poor student would have little trouble in passing Philosophy but would stand a good chance of being "flunked" in English II or Chemistry III.

Table IX.—Showing the Relative Frequency of Four Grades A, B, C, and F as Found by Max Meyer in the University of Missouri in 1907 [1]

Course	Distribution of Grades				Total No. of Students Considered
	A	B	C	F	
Philosophy	55	33	10	2	623
Economics	39	37	19	5	161
German II	26	38	25	11	941
Education	18	38	35	9	266
Mechanics	18	26	42	14	495
English II	9	28	35	28	1098
Chemistry III	1	11	60	28	1903

[1] Max Meyer, The Grading of Students, *Science*, Aug. 21, 1908, p. 3.

The problem educators are now facing in regard to grading students is how to make an "A" or "F" mean the same thing whether given by Prof. Smith or Prof. Brown, whether given in Philosophy or Chemistry, whether given in 1915 or 1917.

An important step toward obtaining equitable grading has been to apply the conception of our normal surface of distribution to the problem. Any group of students (barring exceptional cases considered below) will divide themselves up into inferior, average, and superior students and these three groups will approximate 25%, 50% and 25% in size, respectively. They will do so if the method of grading them is fair. If, however, the examination is too easy or too difficult there will appear not a normal distribution but one in which there are too many superior or too many inferior students, respectively. If in two classes of 100 students, Prof. Smith and Prof. Brown require a *fair* amount of work, then 25% of the students will do superior work, 50% average work and 25% inferior work. If Prof. Smith requires too much and Prof. Brown too little, then it may appear that the former has 40% inferior and 10% superior students whereas the latter has 10% inferior and 40% superior students. If we require each professor to grade 25% of his students superior, 50% average and 25% inferior, then we recognize (1) that one class of students taken as a whole is about equal to any other class and (2) that students are graded in terms of what an average student will do and not in terms of a variable standard of what is required by different instructors. In such a case we know that a "superior" student for Prof. Smith has actually done better work than ¾ of the students in his class and that a "superior" student for Prof. Brown has likewise surpassed ¾ of his class. *A given grade is not then a grade in terms of any absolute standard of perfection but is a grade in terms of what average students do.*

With such a requirement the irregular grading shown in Table IX was eliminated to a large extent at the University of Missouri. The average of all the grades for the undergraduate courses became in 1911, 23.7% superior, 49.9% average, and 26.4 inferior. Nineteen of the instructors distributed their grades as shown in Table X. Comparison of the individual instructor's gradings in this table with those in Table IX shows an enormous improvement in the matter of uniform grading on the part of the faculty.

An "E" now means nearly the same high grade of scholarship whether given by one instructor or another. The gradings in Table X are, however, still too irregular as respecting Grades "I" and "F" to be entirely satisfactory.

The Missouri System of Grading.—As can be seen from Table X, the Missouri system of grading students provides first of all

TABLE XI.—SHOWING THE RELATIVE FREQUENCY OF THE FIVE GRADES E, S, M, I, AND F, AS USED BY VARIOUS INSTRUCTORS IN THE UNIVERSITY OF MISSOURI IN 1911[1]

Instructors	% E	% S	% M	% I	% F
A	7	29	51	8	5
B	5	23	52	15	5
C	3	21	51	21	4
D	7	21	56	8	8
E	6	15	60	13	6
F	1	22	55	17	5
G	2	17	64	11	6
H	3	21	52	18	6
I	3	24	46	21	6
J	3	20	51	20	6
K	3	20	53	16	8
L	3	23	47	17	10
M	2	19	55	14	10
N	4	19	45	23	9
O	5	20	43	21	11
P	7	21	47	9	16
Q	3	13	52	19	13
R	5	11	43	29	12
S	3	15	47	20	15
Average.......	3.9	19.7	51.0	16.8	8.5
	23.6		51.0	25.3	

for the students being divided into three groups—superior, average, and inferior—so that the first group comprises the best 25% of the students, the second group the middle 50%, and the third the remainder. The superior and inferior are further

[1] Based on the "Report of the Committee on Statistics on the Grading of the Semester," Closing Feb., 1911.

divided so that in effect there are five grades of E (excellent), S (superior), M (medium), I (inferior), and F (failure). As illustrated in Plate XXVIII the surface of distribution is so divided that the difference in ability represented by Grades E and S is equal to the difference between S and M, or M and I, or I

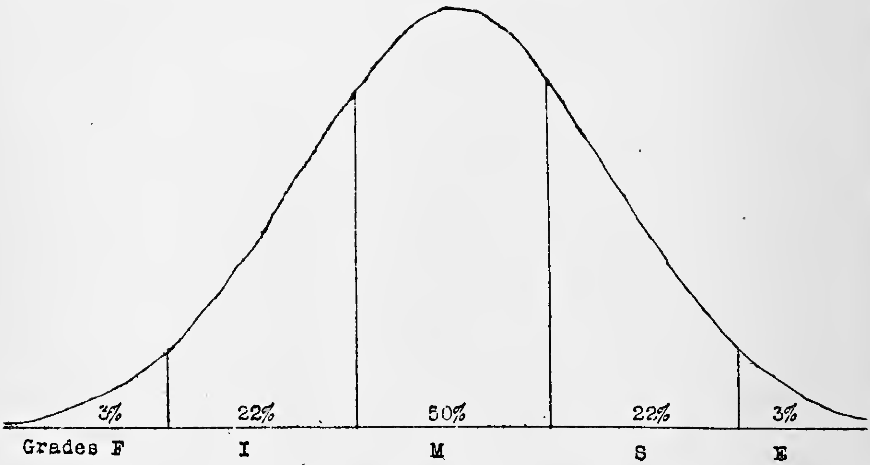


PLATE XXVIII.—A normal surface of distribution divided up into five groups showing five grades of scholarship. At the University of Missouri these five grades are called F (failure), I (inferior), M (medium), S (superior), E (excellent).

and F. The standard which all instructors are expected to reach in their grading is then that 50% of the students shall receive an M, 22% an S, 22% an I, 3% an E, and 3% an F.

One objection to this scheme will immediately occur to some readers. Maybe half the class has actually failed and you have given most of them a C or D. Will that method of marking be fair? Yes, certainly; for if half the class fails, who is to blame? Undoubtedly, in practically every case, no one but the teacher. The examination was too difficult, or too long, or because of poor discipline the students had not studied. This system throws the blame for poor work in the class on the person who deserves the blame—the teacher. Of course, sometimes a group of students will not work, then the only final resort is to "flunk" them. But such cases are rare as compared with those where the trouble lies in the main with the instructor.

Here are the faculty rules of 1917 at George Peabody College for Teachers on this subject. They make plain that the above

system applies directly to large classes and only indirectly to small classes, and possibly not at all to exceptional classes, such as in graduate courses.

"It is fair to assume that the average student in any undergraduate course is equal in ability to the average student in any other undergraduate course. Consequently it is fair to expect that all members of the faculty will in the long run (when they have marked 500 students, say) give approximately the same per cent. of students each of the five grades.

"It is also fair to assume that the calibre of classes does vary, and that this is particularly true in the case of very small classes. Consequently it is fair to expect that the members of the faculty will vary considerably in the way they mark the members of particular classes.

"We expect then in the long run that the members of the faculty will all use the same standards. We also expect, on the other hand, that there will be noticeable variation in the way individual classes will be marked. In the light of these assumptions, the following rules are laid down:

"1. The quality of the student's work in a course shall be reported to the registrar by use of the following grades: A, B, C, D, and F.

"2. The grade of 'C' is designed to represent the performance of the middle 50% of the class. The grades of 'B' and 'D' represent work that is superior and inferior, respectively, to that of the middle group. The grade of 'A' is received for markedly superior work, while the grade of 'F' is designed for those who have failed and shall receive no credit for their work. Students receiving the grade of 'D' will receive but 80% of the full credit attached to the course, i. e., in a five-hour course such a student will receive but four hours credit.

"3. It is recognized that the more advanced the student the more selected is the class with which he will be grouped and the system of marking will vary proportionately.

"4. Experience has shown that in the long run the instructor will give approximately 3% of his students an 'A,' 22% of his students a 'B,' 50% a 'C,' 22% a 'D,' and 3% an 'F'."

Such a uniformity of grades from the members of a faculty is highly desirable and is to be expected so long as it can be assumed that the calibre of students in one class is equivalent to those in another class. If an instructor gives proportionately more low or high grades in his classes than this ideal, he declares in so doing that his students are poorer or better than the students in other classes. This is, of course, in many cases an actual fact, and when so, an instructor should mark accordingly. But in the ordinary course of events one class is pretty nearly equivalent to another class as far as ability of the students composing it is concerned.

Varying the Amount of Credit with the Grade Given.—The University of Missouri further provides that students shall obtain varying amounts of credit for their work according as they obtain high or low grades. At the present time in a one hour course, a student obtaining an E earns 1.2 hours credit, a student obtaining an S earns 1.1 hours credit, a student obtaining an M earns 1.0 hour credit, a student obtaining an I earns 0.9 hour credit, and a student obtaining an F earns 0 credit.

The Carnegie Institute of Technology System of Grading.—Two differences, one significant and one slight, are to be found between the Carnegie Institute of Technology system of grading and that of the University of Missouri. In the former, grades are recognized as of two sorts, those for passing work and those for work below passing. No attempt is made to legislate as to what per cent. of students shall pass in a particular course. That is left entirely to the instructor, or his department, for in many departments the jury system of marking is employed. This is the significant difference referred to above. It rests upon the assumption that an instructor can arrange passing students in order from best to poorest and he can arrange failing students similarly in order of merit, but he can not view passing and failing students as belonging to the same group. Professor Meyer, who has been responsible for the Missouri System and for much of the advance in thinking on this whole subject, writes that he has become "more and more convinced that in determining the final grade the group grade should be applied only after the failures have been selected."

The insignificant difference pertains to the number of grades, and their distribution. At Carnegie Institute of Technology, A and B are given to the best third of passing students, C to the middle third, and D and E to the lowest third of passing students. Distribution based on thirds was agreed upon because it fitted the distribution of all grades given at the time the system was adopted. In addition to the five passing grades, I is given to students whose work has been satisfactory except that part is not yet finished; F to students who are privileged to take a reexamination, and R to students who must repeat the course.

Points for Quality.—Students are required not only to complete a certain quantity of work, but also to attain a certain standard

of quality. The passing grades carry the following points of quality:—A, 4 points; B, 3 points; C, 2 points; D, 1 point; and E, 0 points. A student may pass in all his work but receive too few quality points to meet the requirements and so be dropped.

Present Tendencies in Grading

Among colleges and universities the tendency is away from the percentage system to the group system and to a less extent toward the Missouri system, which has been adopted more or less entirely in a number of institutions.

Among secondary schools, today, 30% employ percentage systems and 65% the group system. Of those using the group system, 44% have three grades above passing, 52% have four grades, and 4% have five grades. The National Conference Committee on Standards of Colleges and Secondary Colleges recommends that, "if a group system is used, the letters A, B, C, or A, B, C, D be employed to indicate passing grades, and that E or F, or both E and F, be reserved for failure. The committee calls attention to the fact that the majority of colleges use four groups above passing, and that the tendency in schools appears to be in that direction.

"The committee recommends that schools using a percentage system follow what appears to be the most common practice, of using 60 as the passing grade.[1]

Discussion of the Problem Assigned in Lesson 26

With these general considerations before us let us turn now and consider the problem which was assigned in Lesson 26.

The Surfaces of Distribution; What They Show.—The grades from the three examinations given in Lesson 26 are plotted in surfaces of distribution in Plate XXIX. The three surfaces approximate the normal surface of distribution. The first one is long drawn out: The effect obtained when the examination is too difficult. The low grades show the same fact. The second distribution is skewed—most of the grades are bunched at the upper end. This is characteristic of too easy an examination or one where nearly all could answer the questions in the alloted time. If the time had been cut in half the distribution would have resembled that of the third examination.

[1] Report in *School and Society,* March 1, 1918, by Headmaster Ferrand.

If we followed the old scheme of marking where, say, 60 was the passing mark, we would, in the first examination, if we were true to our standards and had the requisite courage, fail all but one in the class. In the second examination we would pass every one, and in the third we would fail 17, or 71% of the class. Averaging the three sets of grades we obtain the results given at the bottom of Plate XXIX. These grades would necessitate our failing 14 members of the class, or 58%. If the passing grade were 75 all but one of the class would fail. If it were 50 then 7 would fail, or 29%.

This example is an extreme one, but is based on an actual case. It is, however, useful here as it points out in an exaggerated form the real situation that confronts the majority of instructors in their marking of students' papers. The grades a class actually receives, considering the class as a whole, are dependent on the instructor and him alone. If the examination is difficult the class as a whole gets low grades, if the examination is easy the class as a whole gets high grades. Instructors who mark low are generally instructors who require much from their students, while instructors who mark high do not require enough. Of course, there are many exceptions to this rule. To set up a standard such as 60 or 75 as a passing mark is to postulate that the instructor is omniscient, that he knows exactly how easy or difficult to make an examination.

The best method of grading is to assume that the average student in one class is equal to the average student in another. This assumption is correct remarkably often, as determined by actual investigations. When this is done, *if one is using the Missouri system of grading*, the middle half of the class, regardless of whether they obtain 30, 85, or 50, are graded C. The upper fourth are graded A or B, and the lower fourth, D or F. Theoretically 3% should receive an A and an equal number an F. In actual practice, an instructor should feel free to give no A or F, or several, depending on the circumstances of the case. On the basis of Plate XXIX.

1 student would receive an A, or 4%
6 students would receive a B, or 25%
10 students would receive a C, or 42%
5 students would receive a D, or 21%
2 students would receive an F, or 8%

The A and F grades must depend on circumstances.

In this particular case Student 1 is so far ahead that he alone would be given an "A" unless the work of the class, including 1's work, was not very good. In the same way no grade of "F" might be given if the work of 23 and 24 was acceptable; or if the work was poor 19 might also be given an "F." But in the long

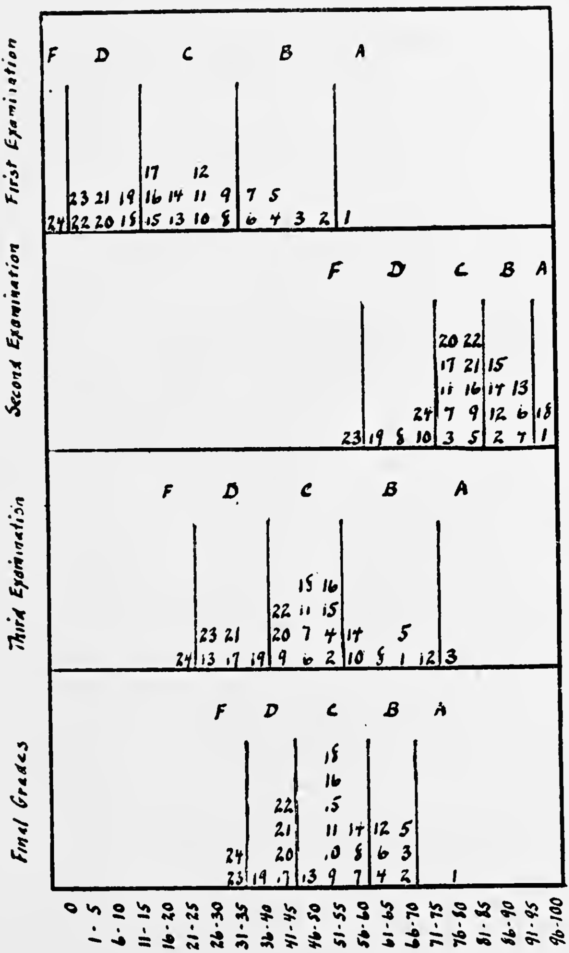


PLATE XXIX.—The examination grades given in Table IX and the computed final grades plotted in surfaces of distribution, together with their conversion into Grades A, B, C, D and F.

run, the instructor should give grades approximately as follows:—A—3%, B—22%, C—50%, D—22% and F—3%.

If one were using the Carnegie Institute of Technology system of grading, the merits of each individual student would be considered, starting possibly with the poorest, and it would be decided whether each had passed or failed. Those who had passed would then be divided into thirds, as described above.

How to Grade Papers

There are undoubtedly many good methods of grading a student's paper. Circumstances will determine whether one will read the whole paper through and grade it as a whole, or whether one will grade each part and then total the parts. The two give about the same result. Regardless of how the papers are individually scored, when that operation is done, one should convert the temporary grades into the grades A, B, C, D, and F. Divide the class into four fairly equal groups. Grade the first group A and B, the two middle groups C, and the fourth group D and F. If there are any exceptionally good or bad papers grade them A, or F, accordingly.

Some instructors find the easiest method is to read the paper through, judge its total value and place it in one of seven piles according to its merit. When all are finished the piles are readjusted if the first two do not contain approximately 25%, the next three 50% and the last two 25%. They are then graded, respectively, A, B, C+, C, C−, D and F. Practically nothing is gained by the subdivision of Group C into three sub-divisions, except to make the instructor feel he is doing a more accurate job.

How to Record Grades.—In Table XI are presented three methods of keeping a class-record. The first method consists in grading in terms of figures from 0 to 100, recording these figures and finally averaging them. This method has little justification. The manipulations of large figures takes too long a time, even when one has an adding machine at his disposal.

The second method consists of recording the letter grades. It is satisfactory, except when it comes to averaging up the records. With only three examinations to average there is little trouble, but if one has to average ten grades, how shall he do it? For example, how would you finally grade students who received (a) A, B, C, C, D, B, C, C, F, and B and (b) B, B, C, D, B, D, C, C, C,

and A? The easiest method of keeping one's record book and a method as reliable as any other is that shown as the third method in Table XI. The letters A, B, C, D, and F are represented

Table XI.—Examination Grades, Given in Table VIII, Averaged by Three Different Methods

Student	First method					Second method				Third method				
	1st	2nd	3rd	Av.	By letters	1st	2nd	3rd	Av.	1st	2nd	3rd	Av.	By letters
1	60	100	70	77	A	A	A	B	A	4	4	3	3.7	A
2	55	90	55	67	B	B	B	C	B	3	3	2	2.7	B
3	50	80	80	70	B	B	C	A	B	3	2	4	3.0	B
4	45	95	55	65	B	B	B	C	B	3	3	2	2.7	B
5	45	85	70	67	B	B	C	B	B	3	2	3	2.7	B
6	40	95	50	62	B	B	B	C	B	3	3	2	2.7	B
7	40	80	50	57	C	B	C	C	C	3	2	2	2.3	C
8	35	70	65	57	C	C	D	B	C	2	1	3	2.0	C
9	35	85	45	55	C	C	C	C	C	2	2	2	2.0	C
10	30	75	60	55	C	C	D	B	C	2	1	3	2.0	C
11	30	80	50	53	C	C	C	C	C	2	2	2	2.0	C
12	30	90	75	65	B	C	B	B	B	2	3	3	2.7	B
13	25	95	30	50	C	C	B	D	C	2	3	1	2.0	C
14	25	90	60	58	C	C	B	B	B	2	3	3	2.7	B
15	20	90	55	53	C	C	B	C	C	2	3	2	2.3	C
16	20	85	55	53	C	C	C	C	C	2	2	2	2.0	C
17	20	80	35	45	D	C	C	D	D	2	2	1	1.7	D
18	15	100	50	55	C	D	A	C	C	1	4	2	2.3	C
19	15	65	40	40	D	D	D	D	D	1	1	1	1.0	D
20	10	80	45	45	D	D	C	C	D	1	2	2	1.7	D
21	10	85	35	43	D	D	C	D	D	1	2	1	1.3	D
22	5	85	45	45	D	D	C	C	D	1	2	2	1.7	D
23	5	60	30	32	F	D	F	D	F	1	0	1	0.7	F
24	0	75	75	33	F	F	D	F	F	0	1	0	0.3	F

in the record-book by the figures 4, 3, 2, 1, and 0, respectively. (Figures are easier to write than letters to begin with, and they can readily be averaged. Contrast the labor involved in averaging them with that of averaging the figures employed in the first method.) Averages between 0 and 0.5 would then be graded F; between 0.5 and 1.5, D; between 1.5 and 2.5, C;

between 2.5 and 3.5, B; and between 3.5 and 4, A. This scheme tends, however, to give too many C's and too few of the other grades. A better method is as follows: Before making out one's final grades, plot the average grades in the surface of distribution as shown in Plate XXX, and award the final grades according to their position on that surface.

A comparison of the final grades awarded in Plates XXIX and XXX shows that they are almost identical. The laborious attempt at great accuracy pursued in the first method of recording grades (see Table XI and Plate XXIX) gives practically the same results as those obtained by the easier third method (see

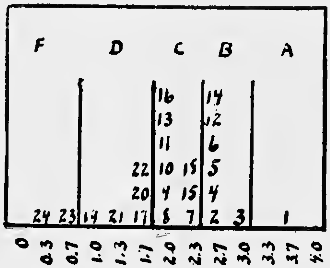


Plate XXX.—The final grades, computed according to the third method in Table XII, plotted in a surface of distribution.

Table XI and Plate XXX). And in the case of Student 14, after all, which is the fairer grade for him, a "C" or a "B"?

A rather technical point ought to be known to teachers. In any system of averaging grades it is possible for a student who has never been graded best in any assignment to obtain the highest average grade, and likewise for a student who has just "scraped through" every assignment, to be graded lower on the average than one who has failed in many assignments. A student who has been consistently B or D (E representing failure) should not necessarily be graded A or E just because A students part of the time have also received low marks or E students part of the time have also received high grades.

Conclusion

We are graded in life not according to some ideal standard of perfection, but in comparison with our fellows, particularly our competitors. Edison is great, not because he approximates

perfection but because he is superior to other men. We have no standard of perfection as such. Our minister, or lawyer, or music teacher, or grocer is superior or inferior in comparison with other ministers, lawyers, music teachers, or grocers we know. The grading of students should be made frankly on the same basis, until such time as *definite standards* have been established and *precise methods* of ascertaining that a student has or has not attained the standard have been developed. At the present time such standards, or norms, have been set up in handwriting, spelling and a few other cases.

LESSON 28

COEFFICIENT OF CORRELATION

In Lesson 20 a preliminary study was made as to whether those who were best at the start were best at the end in such training as doing the mirror-drawing experiment. After we had arranged the ten individuals A to J (see Table III) with respect to their initial and final abilities we found it difficult to express just what the relationship between the two orders was. In this lesson we shall attempt a more satisfactory study of this point.

So far we have considered the average and the average deviation as measurements which help us in our study of individual differences. Still another measurement is needed:—the *coefficient of correlation.* This measurement is needed when we attempt to compare the order of superiority of a group of individuals at one time with their order obtained at another time. For example, in the results obtained from Lesson 20, just what is the relationship between the two orders? On the whole, we can see that those who ree best at the start are best at the end; still there are exceptions. And if, instead of B holding 1st and 4th positions, respectively, he held 1st and 10th positions (i. e., had a final score of 90), we would find it extremely difficult to state just how this change had really affected the entire relationship between the two sets of figures. Here are these two cases:—

Case I (Based on actual data)				Case II (B's data altered)			
Initial	Ability	Final	Ability	Initial	Ability	Final	Ability
B	76	G	35	B	76	G	35
I	129	J	36	I	129	J	36
J	131	I	40	J	131	I	40
C	210	B	50	C	210	E	52
E	216	E	52	E	216	C	58
A	232	C	58	A	232	H	60
G	283	H	60	G	283	A	61
F	286	A	61	F	286	F	70
D	363	F	70	D	363	D	85
H	701	D	85	H	701	B	90

From a study of the two sets of relationships it is clear that there is a closer relationship in the first case than in the second. But it is impossible to estimate this difference by looking at the figures. We need some clear and definite method of expressing such relationships. This is exactly what the coefficient of correlation gives us. Below is an example fully worked out. Study it carefully so as to be able to obtain the coefficient of correlation in similar examples yourself. (Only advanced students in psychology or education are called upon to use correlation, but the term is used very freely in gatherings of educators today and should at least be comprehended by all.)

How to Obtain a Coefficient of Correlation

The several steps involved in obtaining a coefficient of correlation are as follows:—

1. Arrange your individuals in order of merit in the two cases to be studied. (If two or more individuals are tied, then the following scheme is to be followed: Suppose 12 children received these grades in arithmetic—A, 100; B, 90; C, 90; D, 85; E, 80; F, 80; G, 80; H, 75; I, 75; J, 75; K, 75; and L, 70. Then rank A as 1; B and C as 2½ (i. e., the average of 2 and 3); D as 4; E, F, and G as 6 (i. e., the average of 5, 6, and 7); H, I, J, and K as 9½ (i. e., the average of 8, 9, 10 and 11); and L, as 12.)

2. Obtain the differences in the *rank* of each individual in the two ratings (d).
3. Square these differences (d^2).
4. Obtain the sum of these squared differences (Σd^2).
5. Multiply this sum by 6 ($6 \Sigma d^2$).
6. Count up the number of individuals being studied (n), square this number (n^2), subtract 1 from that ($n^2 - 1$), and then multiply the difference by the number ($n(n^2 - 1)$).
7. Divide the amount obtained in the 5th step by the amount obtained in the 6th step.
8. Subtract this decimal from 1.00, observing algebraic signs. This final decimal is the coefficient of correlation.

Here is the solution of the coefficient of correlation of the first set of figures. (Case 1.)

Initial ability		Final ability		Individual considered	Differences in rank	Differences squared
Rank	Individual	Rank	Individual			
1	B	1	G	B	1 − 4 = − 3	9
2	I	2	J	I	2 − 3 = − 1	1
3	J	3	I	J	3 − 2 = 1	1
4	C	4	B	C	4 − 6 = − 2	4
5	E	5	E	E	5 − 5 = 0	0
6	A	6	C	A	6 − 8 = − 2	4
7	G	7	H	G	7 − 1 = 6	36
8	F	8	A	F	8 − 9 = − 1	1
9	D	9	F	D	9 − 10 = − 1	1
10	H	10	D	H	10 − 7 = 3	9
					Total.........	66

Formula for coefficient of correlation (the letter "r" is the common abbreviation for this term):—

$$r = 1 - \frac{6 \Sigma d^2}{n\ (n^2 - 1)}$$

d^2 = the differences squared, illustrated by the ten squared deviations in the last column.

$$r = 1 - \frac{6 \times 66}{10\ (100 - 1)}$$

Σd^2 = the sum of all the squared deviations, as 66 above.

$$r = 1 - \frac{396}{990}$$

$$r = 1 - 0.40$$

$$r = +\ 0.60$$

n = the number of individuals being considered, as 10 in this case, i. e., the 10 individuals, A–J.

The coefficient of correlation (r) between initial ability and final ability in the case of these 10 individuals is +0.60.

Here is the solution of the coefficient of correlation of the second set of figures above. (Case 2.)

Rank	Initial ability	Final ability	Differences in rank	Differences squared
1	B	G	−9	81
2	I	J	−1	1
3	J	I	1	1
4	C	E	−1	1
5	E	C	1	1
6	A	H	−1	1
7	G	A	6	36
8	F	F	0	0
9	D	D	0	0
10	H	B	4	16
				138

$$r = 1 - \frac{6\Sigma d^2}{n(n^2-1)} = 1 - \frac{6 \times 138}{10(100-1)} =$$

$$1 - \frac{828}{990} = 1 - 0.84 = +\ 0.16$$

What a Coefficient of Correlation Means

"Correlation expresses to what extent two traits vary coördinately, independently, or antagonistically."[1] For example, scholarship varies coördinately with intelligence, independently of an alphabetic list of the class and antagonistically to the presence of ill health. In other words, (1) the best scholar is most likely to be the brightest child in the class, the poorest scholar to be the dullest child in the class; (2) the best scholar is no more likely to be the student whose name is Aaron than Zullen, and

[1] Joseph Jastrow, *Character and Temperament*, 1915, p. 509.

the same is true respecting the poorest scholar; (3) the best scholar is most likely to be the child with the least sickness, while the poorest scholar is most likely to be the child with the most sickness.

A coefficient of correlation of +1.00 means that the two traits vary coördinately and perfectly so; a correlation of +0.75 means that the traits vary coördinately but not perfectly so; a correlation of 0 means that the two traits vary independently; and a correlation of −1.00 means that the two traits vary antagonistically. Coefficients of correlation range, then, from +1.00 through 0 to −1.00; any single number having a certain significance on a scale from coördinate variability, through independent variability to antagonistic variability.

The correlation of +0.60 which was obtained between initial performance and final performance in the mirror-drawing experiment means that on the whole the best at the start was best at the end, the poorest at the start was poorest at the end, the fifth at the start was fifth at the end, etc. If it had been exactly this relationship we would have had a correlation of +1.00. As we had less than +1.00, i. e., +0.60, it means that a few of the individuals were out of place from this perfect arrangement. This we find in the cases of G, B, and H; G advancing from seventh to first place, B dropping back from first to fourth place, and H advancing from tenth to seventh. Besides these decided changes in position, all the other individuals except E change place to a slight extent. Now in the case of our second case with its correlation of +0.16, we have a statement which indicates that there is practically no relationship between the two sets of figures. We can expect that only to a very slight extent will it be true that the best at the start will be the best at the end and the poorest at the start will be poorest at the end. Rather will we expect to find decided differences between the two groups of figures such as B's change from first to last place, G's change from seventh to first place, and H's change from tenth to sixth place.

Assignment for Laboratory Hour

Obtain the coefficient of correlation for the problems given below. Do as many of these problems as you can during the laboratory hour. Check up your answer for each example,

through consultation with the instructor, before going on to the next problem.

RECORDS OF TEN INDIVIDUALS IN MIRROR-DRAWING EXPERIMENT

Trials	A	B	C	D	E	F	G	H	I	J
1	232	76	210	363	216	286	283	701	129	131
5	133	70	108	132	110	97	76	98	84	75
10	88	54	71	121	75	89	56	72	55	49
15	89	53	60	86	75	81	43	55	59	38
20	61	50	58	85	52	70	35	60	40	36

1. Obtain the correlation between the fifth performance and the final performance in the mirror-drawing experiment.

2. Obtain the correlation between the tenth performance and the final performance.

3. Obtain the correlation between the fifteenth performance and the final performance.

4. Suppose the following grades had been given to ten students in High School, what would be the correlation between their grades in (*a*) algebra and English, (*b*) algebra and Latin, and (*c*) algebra and biology?

Students	Algebra	English	Latin	Biology
A	98	A	F	83
B	96	A−	D−	94
C	93	B+	D	86
D	89	B	C−	72
E	85	B−	C	91
F	84	C+	C+	88
G	82	C	B−	69
H	80	C−	B	95
I	75	D	A−	77
J	70	F	A	90

5. Answer the following questions:—

(*a*) What does a correlation of +1.00 mean?

(*b*) What does a correlation of −1.00 mean?

(*c*) What does a correlation of 0 mean?

(*d*) Could you have a correlation larger than +1.00 or smaller than −1.00?

6. Study these two statements until you feel that you comprehend somewhat of their meaning:—(1) Two individuals selected at random will have a correlation of 0 with respect to any trait, two brothers will have a correlation of about +0.40 with respect to any trait, and two twins will have a correlation of about +0.80 with respect to any trait. (2) Similarly father and son will correlate about +0.30 while grandfather and grandchild will correlate about +0.16.

Hand in your report drawn up in the usual way at the next class-hour.

LESSON 29

THE CORRELATION BETWEEN HUMAN TRAITS—PSYCHOLOGICAL TESTS

The Relationship Between Human Traits

In our everyday life we are constantly contradicting the principles set forth in Lesson 25. For we speak of people as either good or bad, honest or dishonest, brave or cowardly, blondes or brunettes, tall or short, and so on. In this way, we divide people up into two or more groups. But the conception developed in connection with the surface of distribution was that individuals belong to one group with respect to any trait. We saw further in that lesson that individuals differ greatly in some traits, as in the case of intelligence, where they range all the way from idiots to geniuses. But the great bulk of individuals are all much alike and the number of individuals who differ from the average decreases very rapidly as the amount of that difference is increased.

In our everyday life we are also constantly contradicting another principle already touched on in Lessons 20, 21, and 28. For we assume that poor ability in one respect is *compensated* for by good ability in another. So we say over and over, "I never was any good in mathematics but always got good grades in languages," or vice versa. Or we say of a stupid boy, "He just can't get his school work but it's wonderful how handy he is with tools. You should see the table he made." We really mean in such cases that because the boy can't get his lessons, therefore, he is better than most boys in manual training. It would be very nice if this were the case. But unfortunately it is not. Many investigations in which correlations have been made between ability in two traits have shown that *negative correlations are seldom found.* This means that superiority in one trait is seldom accompanied by inferiority in some other desirable trait. In other words, superiority in one trait is usually

accompanied more or less by superiority in all traits and inferiority in one is accompanied by inferiority in all. Individual exceptions occur from time to time, but not so often as we popularly assume. The correlations between school subjects, according to Starch[1] are as follows:

Arithmetic and Language....	+0.85	Language and Spelling....	+0.71
Arithmetic and Geography...	.83	Geography and History....	.81
Arithmetic and History......	.73	Geography and Reading...	.80
Arithmetic and Reading.....	.67	Geography and Spelling....	.52
Arithmetic and Spelling.....	.55	History and Reading......	.67
Language and Geography....	.85	History and Spelling......	.37
Language and History.......	.77	Reading and Spelling......	.58
Language and Reading......	.83		

Starch goes on to state that "these correlations are almost twice as high as those previously quoted[2] and represent very close correlations. They would warrant the interpretation that the pupil who is good, mediocre, or poor, in a given subject, is good, mediocre, or poor, to very nearly the same, but not equal, degree in all other subjects so far as his abilities are concerned. Such lack of agreement as does exist is due probably to a difference of interest and industry on the part of the pupil in different subjects and to a real difference in abilities in the various fields. Thus spelling ability correlates apparently less closely with ability in other subjects than abilities in these other subjects correlate among themselves."

Many pages of data could be presented to sustain the point that "*intellectual and scholastic abilities are for the most part closely correlated.*"

How Coefficients of Correlation are Utilized in Psychology and Education

The correlations between various school subjects, just quoted, illustrate one use to which this mathematical method of measuring to what an extent two traits vary has been put. Such questions as this one and many others of a similar nature confront the psychologist and educator. Let us consider some other examples where correlation has been used.

[1] D. Starch, *Educational Psychology*, 1920, pp. 56–57.
[2] E. L. Thorndike, *Educational Psychology*, 1903, p. 37ff

The data on initial and final performance in mirror-drawing was reduced to the one figure +0.60, which expresses the extent to which these two abilities vary coördinately.

The writer[1] wished to determine whether the results he had obtained in rating the efficiency of advertisements by a laboratory method would check up with business conditions. He therefore correlated the results he had obtained by two different laboratory methods with each other and with the ratings of these advertisements as furnished him (a) by the owners of the business and (b) by the advertising agency representing the business concern.

He obtained these correlations:—

Correlation between the results of the two laboratory methods	+0.95
Correlation between the results of first laboratory method and the company rating	+0.89
Correlation between the results of first laboratory method and the agency rating	+0.87
Correlation between the results of second laboratory method and the company rating	+0.84
Correlation between the results of second laboratory method and the agency rating	+0.92
Correlation between the company rating and the agency rating	+0.87

Apparently then the laboratory methods of estimating the efficiency of these advertisements were as accurate as the methods of the company or of its advertising experts. That meant that the writer who knew nothing about advertising in those days, nor about this particular business, could determine the efficiency of its advertisements as accurately as could the men who made these things their specialty.

Take another example. Yerkes of Harvard University devised a series of tests (The Yerkes-Bridges Point Scale Test) whereby the general intelligence of children can be estimated surprisingly accurately. Garrison[2] tried the tests on college students and obtained a correlation of only +0.19 between the ratings given the students by the Yerkes test and their college

[1] Edward K. Strong, Jr., *Relative Merit of Advertisements*, 1911, p. 11ff.

[2] S. C. Garrison, The Yerkes Point Scale for Measuring Mental Ability as Applied to Normal Adults, *School and Society*, June 23, 1917.

grades; also a correlation of +0.15 between the test ratings and the combined opinions of eight professors as to the students' general ability. Of course neither college grades nor the combined opinions of professors accurately portray the real ability of college students. We all know that. Still they are accurate enough so that if a test does not correlate with them more than +0.19 we judge that the test is practically worthless. This low correlation means, then, that Yerkes' intelligence test is of little value in classifying *adults* in terms of their general intelligence. It is, on the other hand, as already stated, of real value in classifying children.

When Kelley[1] attacked the problem of how far he could go in prophesying what a student would do in high school on the basis of his records in grammer school, he obtained the correlations between the student's grades in the 4th to 7th grades (a 7-year grammer school was studied) and in the first year of high school. The final correlation was found to be +0.79 between grammar school and high school work. Kelley urges on the basis of his study that the grades of a child should be kept on a card for his entire school career, since they form the very best basis now obtainable from which we can estimate what a child will do in higher schooling. And it is quite likely when we come to know more about vocational guidance that we shall find these records of great value in scientifically guiding boys and girls into the careers for which they are most adapted.

These examples are only three out of hundreds that might be given all going to show how necessary it is to obtain a coefficient of correlation in order to solve many psychological and educational problems. At the present point in this course all that is desired is that you obtain an idea of how the correlation is obtained and something as to what it means. As you progress in your training along psychological and educational lines you will run across this topic again and again and after a time you will commence to feel at home with the subject. What a correlation means is a difficult conception to acquire and cannot be gotten in a few minutes or even in a few hours. It requires time in just the same way that it takes time to familiarize oneself with the centigrade thermometer or the metric system so that the various figures are immediately comprehended.

[1] Truman L. Kelley, *Vocational Guidance*, 1914.

Psychological Tests

One of the fields of research in which correlation has been used most extensively is that of developing tests to measure mental ability. Here we have the task of devising some test and then determining just how closely the scores in the test agree with the measure of the individual's ability in some other respect—the latter is spoken of as the *criterion.* For example, we are interested in devising tests which will determine who can and who can not profit by a college education. When the test scores have been obtained, they are correlated with the grades these same students get in their college work. If the correlation is high, we decide that the test is a good one; if the correlation is low, the test is discarded or radically revised. In this way we test out the test before putting the test scores to use.

Three types of psychological test are employed today:—(1) the intelligence test, (2) the trade or educational test, and (3) the vocational guidance test.

Intelligence Tests

The intelligence test measures the mental alertness of the individual. To the writer the intelligence test measures the ability to learn and to retain what is learned. Possibly, in an indirect way, it is a measure of the chemical changes that take place in the brain which account for learning and retention. Psychologists are pretty well agreed that the capacity which is measured is innate and is very little affected by education or experience.

The most famous intelligence test is that of Binet and Simon, two French psychologists, who first published their test in 1908. Its 1911 revision has been used very extensively. The Stanford revision,[1] the work of Terman, is accepted as one of the best tests of the sort for American children. The six year old test is as follows:—

1. The child is asked, "Show me your right hand," then left ear, right eye, left hand, right ear, and finally the left eye. He

[1] L. M. Terman, *The Measurement of Intelligence*, 1916. (Used by permission of, and by special arrangement with, Houghton Mifflin Company, the authorized publishers.)

must get three correct out of three, or five correct out of six, or no score for this part is credited. If he gets the five correct, it counts "two months," as do each of the remaining five parts.

2. The child is shown four pictures of human beings. In each picture a part is missing, as, the eye, the mouth, the nose, the arms. The child must point to the missing part in three of the four pictures, not consuming more than 25 seconds for each picture.

3. The child must count correctly 13 pennies. He is allowed two trials.

4. He must show his comprehension of two of these three questions:

> (*a*) What's the thing to do if it is raining when you start to school?
>
> (*b*) What's the thing to do if you find that your house is on fire?
>
> (*c*) What's the thing to do if you are going some place and miss your train (car)?

5. When asked "What is that?" and at the same time shown a "nickel," he must reply correctly. Also with "penny," "quarter," and "dime." Three out of four must be named correctly.

6. He must repeat correctly word for word, after one reading, one of the following three sentences, or repeat two of them with not more than one word incorrect in each.

> (*a*) "We are having a fine time. We found a little mouse in the trap."
>
> (*b*) "Walter had a fine time on his vacation. He went fishing every day."
>
> (*c*) We will go out for a long walk. Please give me my pretty straw hat."

The child is given such questions and scored in terms of what he can do. The total gives his *mental age*. Thus, he may be actually six years and six months old but scores in the test seven years and six months. He is spoken of as 7½ years mental age; or one year older mentally than actually.

Another measure is employed in this connection. That is the *Intelligence Quotient* (*I.Q.*). It is found by dividing the mental age by the actual age. In this case it would be 115 (dropping the decimal point).

There are today a great variety of intelligence tests, many constructed quite differently from this one. The test known as Army Alpha was used to grade soldiers during the late war. It contained 212 questions. The numerical score was stated in terms of A, B, C+, C, C−, D, and E. (Refer to Lesson 25 where certain results of this test are discussed.)

Twenty of the 212 questions were simple problems in arithmetic. Sixteen of them were as follows:—Check the best completion to the statement "Gold is more suitable than iron for making money because gold is pretty ( ), iron rusts easily ( ), gold is scarcer and more valuable ( ). Another part of 40 questions necessitated that the word "same" or "opposite" be underlined according as the paired words meant nearly the same, or nearly the opposite. The first and last three pairs were:—"cold—hot," "long—short," "bare—naked," "lugubrious—maudlin," "desuetude—disuse," "adventitious—accidental." (The words "same—opposite" were printed opposite each of the forty pairs.)

The Binet test is typical of an individual test as it is so constructed that it must be given to one individual at a time. The Army Alpha is typical of a group test; several hundred can be tested at one time. Individuals may be easily classified into groups on the basis of one or more group tests. In many cities children are so classified and placed in special classes for the mentally defective, the dull, the average, and the superior. But when careful diagnosis of an individual's mental condition is necessary, this has to be done by individual examination.

Use of Mental Tests for College Entrance.—Considerable interest has been recently aroused by the introduction of mental tests as part of the machinery for deciding whether this or that student should be admitted to college. The time has not yet arrived definitely to evaluate their use in this connection. But let us consider one such study by Thurstone[1] as to the relationship between scores in mental tests and scholastic work in college.

The Freshman students in the Margaret Morrison College of Carnegie Institute of Technology were given six different tests and the scores combined into one final rating, so calculated as to range from −25 to +105. The distribution is shown in Plate

[1] L. L. Thurstone, Mental Tests for College Entrance, *Journal of Educational Psychology*, 1919, pp. 129–142.

XXXI. The lower *critical score* at +10 was selected so as to divide off "the largest proportion of failures without excluding any students who have made good." If the Freshmen who fell below this critical score in their test papers had all been refused admission then seven out of the eleven who were flunked out would have been eliminated at the start. Furthermore, eight of the seventeen who were placed on probation for poor scholarship would have been eliminated. And at the same time, not one of the students who was able to carry the work would have been prevented from getting a college education. It would probably

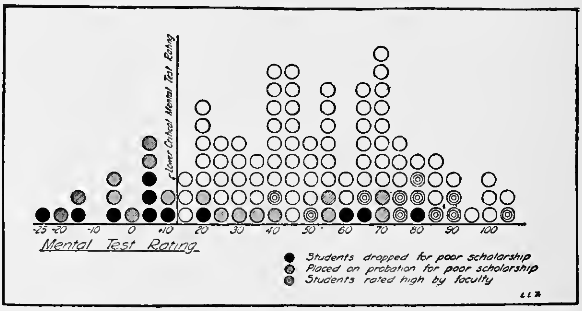


PLATE XXXI.—Showing distribution of Freshmen in terms of mental test scores; also the scholastic records of the young women.

have been better to save these fifteen young women the discouragement which comes from failure and to advise them to take up some other work.

In Plate XXXII we have what is technically called a *scatter diagram.* On it each Freshman is shown as a dot, so placed as to indicate (*a*) the intelligence test rating and (*b*) the combined estimate of her instructors. (These estimates range from 1 to 10, 10 being the highest estimate.) Thus the student at the extreme lower left hand corner received a mental test rating of −20 and the instructors' estimate of 1, whereas the student at the extreme upper right hand corner received a rating of +105 and an estimate of 10. The correlation here between intelligence test ratings and combined instructors' estimates is +0.60.

Two critical scores are shown in this plate. All the Freshmen rated below the lower critical mental test rating (+10) are below the average in the opinion of the faculty and all who scored above

the upper critical mental test rating (+85) are rated above the average in the opinion of the faculty.

The correlation of +0.60 tells us here how close the relationship is between test ratings and the instructors' estimates. The critical scores mark those points at which we can divide the group into three parts, so that all the inferior students in both

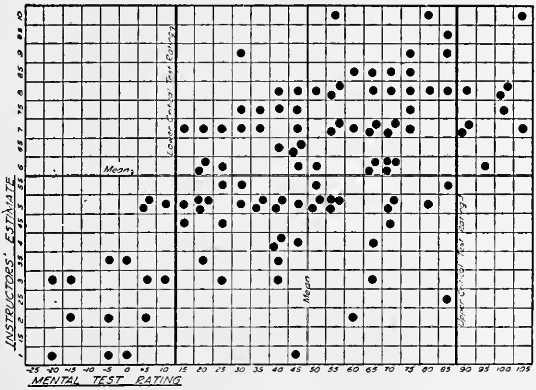


PLATE XXXII.—Scatter diagram showing relation between instructors' estimate and mental test rating.

test and instructors' estimates are at one end, all the superior students in both cases are at the other end, and the remainder of the students are in between. Such conditions are essential if good diagnostic results are to be obtained.

TRADE AND EDUCATIONAL TESTS

What is needed in schools and industry is tests that measure ability to do certain specific work, such as column addition, with a specified degree of speed and accuracy, handwriting of such and such merit, driving an auto truck up to standard requirements, or doing the work of a journey man carpenter. Such tests differ from intelligence tests as discussed above for they measure specific ability (or performance) to do a definite task at this time, not general ability. The Kansas Silent Reading Test (Lesson 21) is typical of many educational tests. Plate XXXIII shows a portion of the Thorndike Handwriting Scale. The handwriting of any individual can be compared with the specimens in the scale and graded accordingly.

The norms proposed for handwriting in terms of this scale are:—

Grade	II	III	IV	V	VI	VII	VIII
Speed[1]	35	45	55	64	72	77	80
Quality:							
Usual	7.0	7.8	8.6	9.3	9.9	10.5	11.0
Best	8.5	9.3	10.1	10.8	11.4	12.0	12.5

During the war thousands of soldiers were trade-tested in order to determine how good they were along certain occupational lines of value to the army. Men claiming auto truck driving experience, for example, were required to drive a truck over a standardized course on which they were scored on certain specified points, as, for example, driving forwards and then backwards over an S-curve without running off the road. In this way the truck driving ability of each of such soliders was measured according to a standardized procedure and so expressed that every trade-test officer understood just what it meant. (Contrast this highly standardized method of measurement with our present inability to state what a 4th or 12th grade student can do.)

Vocational Guidance Tests

Vocational guidance tests differ from both intelligence tests and trade tests in that they are made to indicate *future* ability to do certain *specific* work after the individual has been trained

[1] Speed indicates "letters per minute" without substantial loss in quality of writing, when the material being written is so familiar as to require no time for study or reflection, and when the total time of the test trial is not over three minutes.

Usual Quality, the quality used by the pupil in history, geography or composition papers, is probably a better practical index of efficiency than the writing done in the writing class or under instructions to "write as well as possible."

Best Quality indicates the quality written when the instructions are to "write as well as you can." The above standards are the medians that may reasonably be expected at the middle of the second half year in each grade, where the school is fairly typical of American public schools in its population and is well organized.

for the work, whereas intelligence tests measure *general* ability to learn and retain, and trade tests measure *present*, not future ability. When really serviceable vocational guidance tests have been developed it will be possible to foretell whether an individual can make good or not along this or that line.

Very few such tests are in existence today. Probably the best developed series is that of Seashore[1] for determining musical ability. The Bureau of Personnel Research at Carnegie Insti-

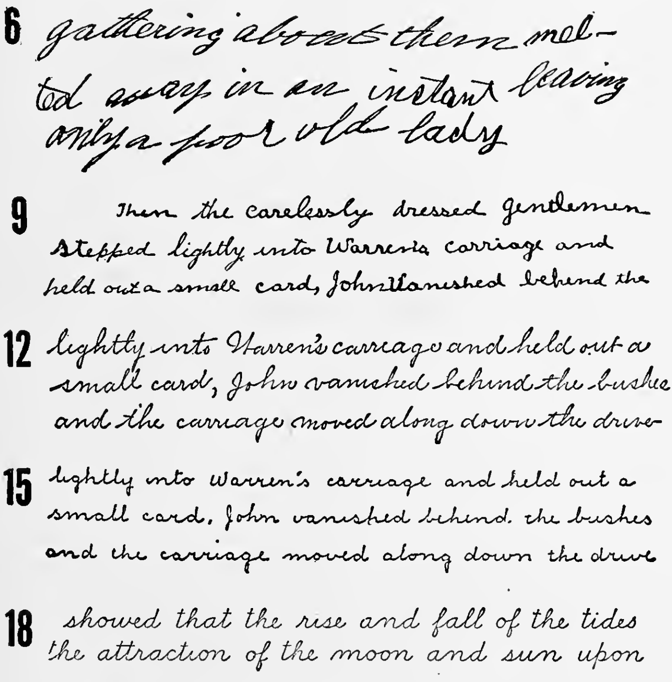


Plate XXXIII.—Samples taken from Thorndike Scale for Handwriting.

tute of Technology is engaged in developing trade and vocational guidance tests which will indicate whom to hire and whom not to hire as salesmen for life insurance companies. In Plate XXXIV is shown one of the latest developments in this field. Seventy-five men and women in the School of Life Insurance Salesmanship were given five tests and an extensive application blank to fill out. The combined scores from all six blanks are

[1] C. E. Seashore, *Psychology of Musical Talent*, 1919.

expressed in figures from -11 to $+24$. Later the production records of these individuals were obtained and checked against the test scores. The plate shows quite clearly that the methods employed here by Ream and Yoakum have high predictive value as to who can pass the course and who will sell insurance after they graduate.

Interest Analysis.—In addition to intelligence tests, interest analysis blanks have been found very useful as a part of trade

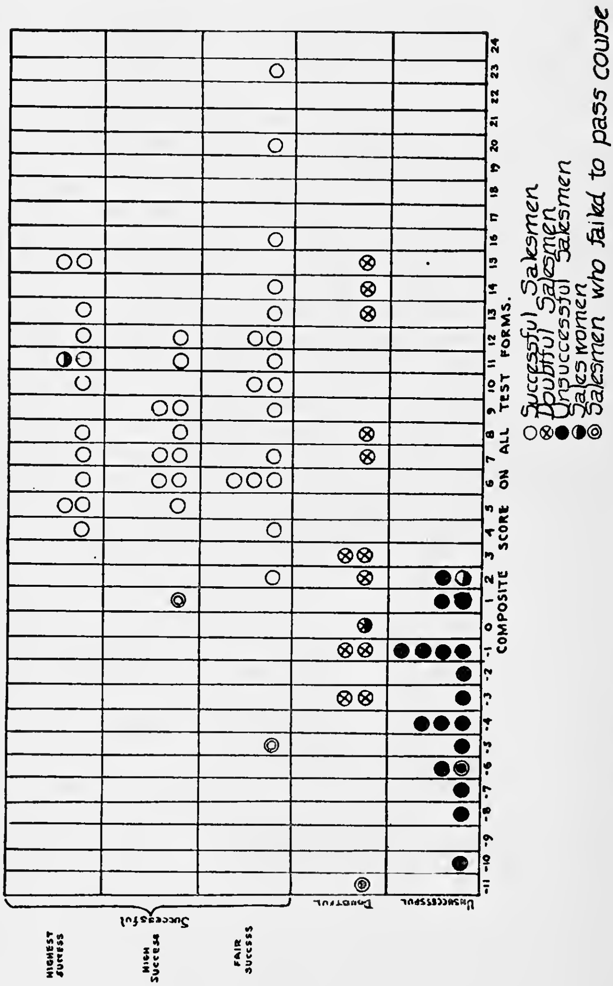


PLATE XXXIV.—Success in selling life insurance, predicted from scores in Tests VI, IX, XI, answering Objections, Interest Analysis, and Personal History.

and vocational guidance tests. Here the applicant is given a list of items arranged in groups, such as:—

actors	fat men	sporting pages
architect	fat women	love stories
artist	thin men	detective stories
astronomer	thin women	Harold Bell Wright
auctioneer	tall men	Life (the magazine)

After each item he is asked to indicate his reaction to it by a letter; L, if he likes the object in question; D, if he dislikes it; O, if he has no decided feeling; and U, if he has no knowledge of the item.

Men who become successful life insurance salesmen like the following:—outdoor work, working with people, people with opinions opposite to one's own, fashionably dressed people, children, ministers, lawyers, conservative people, working alone, talkative people, etc. An individual, it has been found, is not so likely to succeed, if he likes the following:—being an architect, or draftsman, or auto repair man; working with things, writing personal letters, cautious people, carelessly dressed people, gamblers, undertakers.

At the present time theories are out of place as to why such likes and dislikes have anything to do with selling. The fact of the case is that they are of diagnostic value.

LESSON 30

SUMMARY OF LESSONS 19 TO 29

The first part of this text-book has dealt with the learning process, and the second part with individual differences. A third general conception has been developed as to the meaning of Situation, Bond and Response. These conceptions can be schematically represented by the learning curve, the surface of distribution and by the letters S–B–R.

What has been covered in this second part may be grouped under six main heads:—

Causes of Individual Differences

A great number of factors combine to produce any one individual. How many these are and what they are is largely unknown. The thyroid gland has been pointed out as one such factor. But there is little ground to believe that it is a factor independent entirely of other factors; rather it is to be supposed that it affects many other factors and that they in turn affect it.

All the factors that affect an individual and so cause him to differ from other individuals may be grouped under the two heads of heredity and environment. Each individual is born with a certain combination of factors. And each individual is confronted with a different environment from all of his fellows. What he finally becomes is due to the effect of these two. The modifications of his native behavior due to efforts to adjust himself to his environment is called training. Training is thus always a composite of heredity and environment. In lessons 31 to 50 many additional facts will be pointed out showing just how heredity and environment contribute toward training.

How Individuals Differ

Contrary to popular notion, men do not divide up into two or more sharply defined groups or types. Instead, in nearly every

case, they are found to all belong to *one type.* But not all members of the type are alike; they all differ more or less. Their differences may, however, be viewed as variations from a central tendency, or average individual. And, moreover, many individuals are found to differ only a little from this central tendency and only a very few individuals to differ greatly from it. The normal surface of distribution pictures this conception.

In comparing individuals who belong to different groups, such as whites and negroes, or army officers and enlisted men, or fourth grade and eighth grade children, it is found that members of the two groups *overlap;* that seldom is there a sharp break between two groups. So true is all this that it is extremely difficult to find methods to distinguish between members of different groups. But until such methods are discovered the sciences of employment management and vocational guidance cannot be established.

In the specific field of learning, individuals differ with respect to initial performance, amount and rate of learning, and final performance. The effect of heredity and previous training upon these three has been pointed out.

How Traits or Abilities Within One Individual are Related

Here, again, popular opinion has been found to be in error. An individual who is superior in one trait tends to be superior in many traits. Nature does not usually *compensate* for weakness in one ability by developing another to make up for it. In other words, desirable traits, for the most part, correlate.

There is, however, considerable truth in the popular view, when viewed from another angle. The child, for example, who is awkward in athletic games goes off and does something else. Later in life he may be noted for the musical talent which would not have been developed if he had played like other boys. The key to an understanding of many a person's behavior is a knowledge of his former failures, for by now they are covered up as well as possible and compensated for through interest in other activities. Often, although not always, the failures remain sore points and unexpected reactions occur when they are touched upon. The story in Lesson 1 of the man who objected to the

church bells is an example of an unexpected reaction because of the soreness of failure.

The Basis from Which to Measure Individual Differences

Any group of individuals, barring exceptional cases, are distributed about a central tendency, as pictured by a surface of distribution. The natural point from which to measure how each individual differs from the group is this central tendency, or position of the average person. Each individual can then be thought of as so much superior or inferior to this central tendency. Now this is just what a man ordinarily does when he expresses a judgment about another. He states that the other one is tall or short, good or bad, educated or uneducated, in terms of his notion of what an average man is in that respect. So the most prominent minister, or doctor, or school teacher, or carpenter in a small town is rated very superior, just because he is superior to the average in the town. In terms of average ability in his line in the state he may be quite inferior. But an interesting aspect of such judgments is that the average man does not realize he is making judgments in terms of a central tendency; he thinks he is making them in terms of perfection. Grades in school are always viewed as expressing the percentage of perfection attained by the child. The two lessons on grading students make clear that this is not and cannot be the case.

Norms have recently been developed to enable judgments to be made in terms of definite standards which all can understand. A norm, we have seen, is a measure of what an average person can do, based on measurements of a large number of individuals. So we have today norms for the various grades in certain work in arithmetic, for handwriting, spelling, and the like. In the future norms will exist for a great deal of school work and for much in industry. A norm is not, however, a standard of perfection, but a standard in terms of average performance.

In the field of testing general intelligence, or mental alertness, mental age is employed as a measure. It is often divided by actual age giving a quotient or ratio, called the I.Q. The intention is to have this I.Q. so standardized that the decimal 1.00 will represent normal ability, i. e., the proper mental develop-

ment for the individual with that actual age. And the word "proper" means in this connection that mental development which goes on the average with the given actual age.

Statistical Tools in the Study of Individual Differences

An introductory psychology is not the place to stress statistical methods. But without comprehension of certain statistical tools one can hardly understand many important facts and principles dealing with individual differences.

There are three measures of the central tendency. Everyone is familiar with the *average* of a set of figures. But few are at all familiar with the other two measures—median and mode. The method of obtaining them can be illustrated from the data given in Table VII. The *median* means the middle datum when all the data have been arranged in order of merit. Thus the median performance in the fourth grade would be 6 problems attempted and 3½ problems solved correctly, for 50% of the pupils did better, or equal to, 6 and 3½ respectively, and 50% did poorer, or equal to, these two medians. The *mode*, on the other hand, means that performance which is typical of the largest number of individuals. Thus, the mode would be 6 problems attempted (21% did 6 and only 14% did 7 or 5) and 3 and 4 solved correctly (14% did both 3 and 4). In the latter case there are two modes, is quite often the case.[1] The mode is not used very often, but the median is used very frequently in the field of educational psychology. It has this decided advantage over the average that it tells at what point a class, for example, is divided into two equal parts, so that half of the students are superior to the median and half inferior.

Measurement of variability of a group from its central tendency is obtained by the average deviation. There are other measures but lack of space forbids mention of them.

A complete expression of both central tendency and variability is afforded by the surface of distribution.

[1] The student who is interested will find it worth while to refer to E. L. Thorndike, *Theory of Mental and Social Measurements*, 1913; H. O. Rugg, *Statistical Methods Applied to Education*, 1917; or C. Alexander, *School Statistics and Publicity*, 1919.

The relationship of one trait to another is measured by the coefficient of correlation. It may be pictured by a scatter diagram.

Methods of Measuring Individual Differences

When considering psychological factors, individuals are usually measured from a central tendency or norm. But they are measured by means of some test. When a measure of general native ability is desired, some form of intelligence or mental alertness test is employed. When a specific native ability is to be measured the appropriate vocational guidance or aptitude test is employed, and in some cases an interest analysis blank is also used. When a measure of training along some line is desired, the appropriate trade or educational test is used. The better the aptitude test is, the more it measures ability in the one trait under study and the less it is affected by ability in other lines. Similarly, the better the trade or educational test, the more it measures specific training as expressed in doing a certain performance and the less it is affected by general ability.

Certain general applications naturally follow:—

Application to Some Educational Problems

Learning has been reduced to making connections—forming new bonds. And *teaching* consequently becomes the art and science whereby proper situations are presented so that children will react as desired. In so reacting new bonds are constantly being formed and old bonds as constantly being strengthened through use.

The problem of individual differences is a very big problem in the educational world and must be taken into consideration in teaching and administrative work. Children differ very materially. Such differences are caused jointly by heredity and by training. The differences in training can to a large degree be taken care of through putting those with extra training ahead of those with less training. But the differences due to heredity cannot be disposed of so easily. Superiority in heredity means that the child is going to advance rapidly; inferiority in heredity means that the child is going to advance slowly. This is shown

diagrammatically in Plate XV. It means that any class always tends to fly apart. The more training a group has, the more the children are going to become unlike. Training does not make people alike, it makes them unlike. The bright child gets all of his lesson, the dull child but half. The next day the bright child gets all of the new lesson; the dull child cannot do as well as he did before, because part of the new lesson depends on that part of the first lesson he didn't get. He consequently gets less than half of the second lesson. So as time continues the gap between the two widens.

As things are conducted today, average children are fairly well taken care of. The pace set is too slow for the bright children and too fast for the dull children. The bright children are not encouraged to work hard. They can easily get their lessons in a few minutes "any old time." The dull are discouraged for they can't possibly keep pace. What is needed today is a system so elastic that all can keep working at their own pace. Some advocate here that the pace be set for the dull child and the better children be persuaded to do more work on the side and in a better manner. The dull child will then get the sheer essentials, the others a richer and richer course depending on their ability. But how is such a course to be conducted? Others advocate various schemes for rapid or slow promotion depending on the different children.

With the use of an intelligence test the innate mental alertness of each child can be determined. Such results are being used to solve this problem of properly grading children. In this way children of the same intelligence are put together. Such a plan is easily workable in a large city school system where there are several sections in each grade anyway. It is not so easily applied to small school systems.

Another problem is immediately brought to the fore as soon as such a classification of pupils on the basis of intelligence is accomplished. Shall the bright pupils be allowed to finish the grammar school in considerably less time than average children? Many have advocated this. Others have advocated an enriched curriculum for the brighter children so that they will spend the same time in each grade that average children spend, but cover much more ground. The best argument in favor of the latter program is that bright children may be superior to average chil-

dren in intelligence, yet many of them are no more advanced than the average child in emotional development. And the child's best social development comes from having him with those of the same emotional development. If high schools and colleges should sometime be organized to take care of highly intelligent but socially immature pupils, then it might be wise to force bright children ahead; but until that time, an enriched curriculum seems to the writer the best procedure in the handling of superior children.

One teaching device based on the principles covered in this test should be considered in this connection. It is embodied in the *Courtis Standard Practice Tests.* These are drill blanks given to children in the grades and so arranged that each child can progress as fast as he is able, but the whole class is kept busy at the same time. The first two tests and the record sheet covering these tests are shown in Plates XXXV and XXXVI. On the first day every child is given a copy of Lesson 1. Suppose it is a 4th Grade class. The children are then allowed 6 minutes to do the lesson.[1] At the end of the six minutes the papers are corrected and each child records his record in his Record Book. On the second day, if any child finished the first lesson correctly within the six minutes he is not required to do Lesson 1 over again but is supplied with Lesson 2 instead. The remainder of the class repeat Lesson 1. So it goes throughout the year. It is conceivable that after forty-eight days a very bright child would have entirely finished all 48 lessons whereas a very dull child would still be on the first lesson. Courtis, however, advocates that after several failures, individual instruction be given the backward child and if that is not sufficient to bring him up, that he be allowed to go to the next lesson. In Plate XXXVI are shown two individual records on the one sheet. (Ordinarily only one record would appear on a page.) N has required 15 days in which to finish Lesson 1. The solid line traces the number of problems he did each day and the broken line the number he got correct. M, on the other hand, finished Lesson 1 in five days and Lesson 2 in two more days. (As there are but 61 problems in Lesson 2, 61 is of course the standard set in that lesson.) His record for Lesson 3 would be scored on another page

[1] The other grades are given a shorter time. The 5th grade is allowed 4¾ min.; the 6th grade 4 min., the 7th grade 3½ min., and the 8th grade 3 min.

and so does not appear here. He finished up four lessons while M was doing one.

The point to be noted about this scheme is that it provides a method by which the entire class can be put at arithmetical work

LESSON No. 1—ADDITION

Name____________________ Grade________

6 3 1	8 4 7	4 7 4	2 4 6	5 0 2	6 7 5	4 2 3	3 6 8	4 9 6	4 2 9	9 6 8	5 0 6
1 8 3	8 1 5	3 4 9	7 2 4	7 0 1	1 7 7	5 2 6	5 1 9	5 9 2	1 3 9	8 7 8	7 5 2
6 5 5	5 2 6	3 9 8	7 5 4	8 0 8	1 8 9	6 7 6	8 1 3	6 2 1	4 8 5	3 8 7	7 6 6
9 3 2	7 0 4	4 4 8	9 7 3	9 6 5	5 6 9	5 1 6	2 4 8	4 5 9	7 2 8	3 9 9	8 9 3
4 7 4	3 4 8	4 9 7	5 1 8	9 7 0	4 9 3	4 3 1	1 3 8	5 1 5	9 2 3	6 5 8	5 4 7
8 4 0	9 3 6	5 0 8	8 8 5	5 3 2	3 6 4	3 3 1	5 6 8	9 7 5	1 6 7	3 9 4	8 6 0

LESSON No. 2—SUBTRACTION

Name____________________ Grade________

19 6	32 7	14 2	32 3	12 2	23 9	35 7	13 1	31 4
15 5	17 2	33 7	19 8	30 2	27 7	16 2	26 7	26 5
21 8	37 9	12 1	29 5	25 9	28 1	18 3	27 6	26 8
29 9	18 5	31 6	20 9	32 6	14 4	17 3	37 8	24 7
13 2	38 8	31 7	27 5	21 5	19 1	24 5	14 3	30 3
21 2	33 8	20 1	29 3	32 4	15 4	26 6	30 6	
18 2	28 9	14 1	29 4	11 1	32 9	23 6	15 1	

PLATE XXXV.—Courtis Standard Practice Tests.[1]

and at the same time the lessons may be varied in accordance with individual differences. Moreover each child plots his own

[1] The latest edition of these practice tests shows Lesson No. 1 as above. But Lesson No. 2 now comprises 70 problems instead of 61. The Graph Sheet in Plate XXIX is also from an earlier edition of the "Student's Record and Practice." (By permission of World Book Company.)

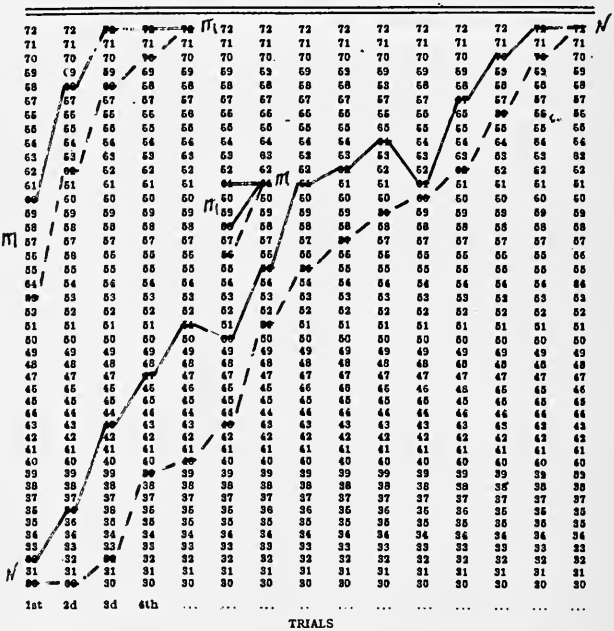
learning curves and so knows just how he is advancing day by day. He has the stimulation of racing against others and also against himself. This whole procedure is typical of a general method that can be employed by most teachers.

GRAPH SHEET

FOR

Lesson No. 1 . . 72 examples Lesson No. 2 . . 61 examples

LESSON NO.



INSTRUCTIONS: After each trial, in the column corresponding to the number of the trial, draw a short horizontal line through your score in examples tried. Using a ruler, draw a heavy line from this point to the score marked in the previous column. In like manner draw a curve for Rights, using a heavy broken line. More than one graph can be drawn on this page; see Model, page 4. When you have completed the lesson successfully, hand in this record book with your paper.

PLATE XXXVI.—Graph sheet. Showing record of two children, M and N. M finishes Lesson No. 1 in 5 days and Lesson No. 2 in two days more. N requires 15 days to complete Lesson No. 1 in the allotted time.

An entirely different scheme for providing for individual differences is utilized in this course. Each lesson contains as many "leads" as even the best student will have time to follow. Every minute devoted to study is sure to add something to his training or store of information. At the same time each

lesson is easy enough so that the poorest student, deserving only to pass the course, can obtain sufficient grounding in the fundamentals of the course to pass and go on. The better the student, the more thorough a grasp of the material will be obtained, but all will get a worth while amount. If two or three times as much time were devoted to the course, the poorer students would get more from the course, but the better students would not be kept busy and so would not get the maximum training they have a right to receive in return for their tuition and time.

Realization of what this problem of individual differences means gives us a new point of view with regard to the whole subject of education. The overlapping of children in the several grades is being studied from many angles and ere long a more satisfactory solution of this phase of individual differences will appear. The old schemes for grading students are doomed and new ones based on our further knowledge of how children differ are taking their place. Because of better and better understanding of what each child can do and is best fitted for, there will result less antagonism to education and social authority and happier children, parents, teachers and supervisors.

Not only are the problems of education viewed in a new way but also all social problems. The handling of criminals, of paupers, of incompetent workers, of insane, of all exceptional individuals, has become a different proposition. Changes in our penal institutions, the rise of Juvenile Courts, of indeterminate sentences, of parole from penitentiaries, the interest in eugenics, in scientific vocational guidance, in personnel work, etc., are all related to each other—all manifestations of the view that individuals are not all alike nor can they be divided into sharply contrasting types, but that all are merely variations of greater or less degree from the average.

The student who has not simply learned about these things but has formed the habit of analyzing educational problems into situations and responses has gained something which will help him in all his work. As an aid in making such analyses this course has been devised so as to develop habits of solving problems by asking these questions:

1. What specifically is my problem?—the problem.
2. How may I study this problem?—the procedure.

3. What are my facts?—the results.
4. What do the facts mean?—the interpretation.
5. How can I use the deductions?—the applications.

Whether a student has got these things from the course or not eventually comes down to whether he has the ability to acquire such complicated conceptions (bonds) and has had the industry to develop them.

INDEX